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INTERIM SITE STABILIZATION AND CLOSURE PLAN FOR THE BARNWELL LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY 2000 CLOSURE PLAN

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1.0 INTRODUCTION

Chem-Nuclear Systems (CNS) operates a low-level radioactive waste disposal facility located approximately five miles west of the town of Barnwell, in Barnwell County, South Carolina. The site comprises approximately 235 acres of property owned by the State of South Carolina. The site is leased from the Budget and Control Board of the State of South Carolina, which will become the custodial agency after burial operations and site closure have been completed.

The disposal facility is operated under South Carolina Department of Health and Environmental Control (DHEC) Radioactive Material License No. 097 (License No. 097). The license specifies requirements for receipt, handling, and disposal of radioactive waste and delineates the requirements for operation of the site as a low-level radioactive waste disposal facility.

1.1 Purpose

The purpose of the Interim Site Stabilization and Closure Plan (the Closure Plan) is (1) to describe activities required to close and decommission the site, (2) to provide a cost estimate for closure activities and compare it to the amount in the decommissioning fund, (3) to document activities to be performed during the long-term care period, (4) to provide a cost estimate for long-term care and compare it to the amount in the long-term care fund, and (5) to perform a re-assessment of operating practices to ensure that on-going activities are consistent with proposed closure activities and goals.

The Closure Plan provides a documented path of actions leading to stabilization and final closure of the Barnwell Low-Level Radioactive Waste Disposal Facility (Barnwell site). After stabilization and final closure, the site must continue to meet performance objectives specified by License 097. The plan discusses the disposition of the buildings and structures on the leased property, the planned disposal area stabilization activities, and the closure performance objectives. The planned post-closure maintenance and monitoring of the site, and the availability of funds for all these activities, are also discussed.

1.2 Scope

This document is a revision and update of the 1999 Closure Plan. CNS has provided this update to make the document consistent with the Atlantic Interstate Low-level Radioactive Waste Compact Implementation Act (S1129), which became law effective July 1, 2000. The Closure Plan reviews major aspects of the Barnwell site's operations and outlines plans for facility closure, post-closure observation, and long-term care. S1129 establishes time frames for operations upon which this plan is structured. CNS has designed its approach for closure to be consistent with these time frames as shown on Figure 1-1.

CNS assumes four fundamental time periods during the life of the disposal facility.

(1) Eight years of operation receiving LLRW disposal volumes up to that allowed by S1129. This period extends from FY 2000/2001 to FY 2007/2008.
(2) Thirty years of operation as an “in-region-only” disposal facility. The initial two years of this period (Phase I closure) will be used to complete closure activities on most of the disposal site, followed by a five-year post-closure observation period (Phase I post-closure) for closed parts of the site. As additional areas are completed during the thirty-year period, they will be closed. CNS assumes this period will end in 2038 recognizing that the in-region-only period may extend less than or beyond thirty years depending on site capacity and other considerations.
(3) One year in-region operations final closure (Phase II closure) and five year in-region period final post-closure observation (Phase II post-closure) following in-region operations.
(4) One hundred years of institutional control following the Phase II closure and post-closure periods. CNS assumes institutional control will end in 2144.

This plan provides detailed information for current operations and Phase I closure and post-closure observation.

THIS FIGURE (FIGURE 1-1: BARNWELL SITE PROJECTED TIMELINE) AVAILABLE IN SEPARATE ELECTRONIC FILE.

2.0 HISTORICAL BACKGROUND

This section reviews the history of regulatory actions, legislative actions, the licensed disposal area, trench construction and maintenance, waste characterization and packaging and radionuclide inventory.

The section traces the evolution of the site, reviewing how these aspects have been affected by regulatory and political changes. The elements of Section 2.0 provide the perspectives under which this revision of the Closure Plan has been developed.

2.1 Regulatory Documents

Four major documents have governed the Barnwell site, its operation and disposition since CNS was licensed to store waste in 1969. These documents are the Lease Agreement and its amendments, South Carolina Radioactive Material License 097, U.S. NRC Radioactive Material License No. 12-13536-01 and the Decommissioning Trust Agreement of 1981.

Lease Agreement and Amendments: CNS entered into a 99-year lease agreement with the South Carolina Budget and Control Board on April 21, 1971, to lease 17.2 acres of land, previously deeded to the State by CNS, for the purpose of burial of radioactive waste. Under this agreement, CNS agreed to operate in accordance with its license application, the conditions of its License 097 and the requirements of the U.S. Atomic Energy Commission. The agreement also established a fund for the long-term care of the site. CNS agreed to pay eight cents into the fund for every cubic foot of waste received for burial.

The Lease Agreement was amended on April 6, 1976, replacing the previous agreement and expanding the lease area to its present 235 acres. At the same time, the long-term care fund payment was increased to sixteen cents per cubic foot. The agreement included a formula for increasing the fund based on the Consumer Price Index. Since 1976, the payment to the long-term care fund has increased to $2.80 per cubic foot of waste. Other conditions of the lease have remained substantially the same.

South Carolina Radioactive Material License 097: The most important document affecting operations and closure of the site, License 097 was issued by DHEC in 1969 authorizing receipt and storage of low-level waste. Following extensive geohydrological investigations the license was amended in 1971 to authorize disposal of low-level waste by shallow land burial. State and federal agency involvement and DHEC approval preceded authorization for burial.

License 097 specifies requirements by which CNS operates the disposal site. The license describes trench construction specifications, backfilling and capping requirements, and required trench markings. Requirements for acceptable wastes are covered as well as specific documentation that must accompany each shipment from the generator. Waste shipments and vehicles must comply with United States Department of Transportation (DOT) regulations for transport and receipt at the site and even more stringent license conditions for acceptance, burial and vehicle release.

The DHEC license has been amended forty-eight times since it was issued in 1969. Amendments cover a range of changes, from modifying a single license condition to a complete rewrite consolidating several previous amendments into a single document. Due to the straightforward and open policy CNS has with DHEC, the amendments have resulted in positive changes and improvements to the burial site and its long-term integrity. An application to renew the license was submitted to DHEC April 28, 2000 and is currently under timely review.

NRC Radioactive Material License No. 12-13536-01: In 1975, this license for receipt and disposal of special nuclear material (SNM) was issued to CNS at the Barnwell site. The main purpose of the license was to allow CNS to receive larger quantities of SNM than permitted by the State license. Agreement States cannot authorize receipt of SNM in amounts greater than allowed by the U.S. Atomic Energy Act of 1954, as amended.

The larger possession limits of SNM, mainly uranium-235, allowed waste generators to ship full loads rather than partial loads of the same waste materials to the site and provided for some storage capabilities for SNM wastes if required by inclement weather or lack of trench space. The license specified a total unburied possession limit of 4500 grams for U-235 and 200 grams for U-233. In addition, the license imposed a maximum quantity of 350 grams of U-235 and 200 grams of U-233 per package. On January 1, 1990, the DHEC license was amended to eliminate the disposal conditions related to SNM wastes because they were already covered under the NRC license.

Because the number of SNM waste shipments to the site had dropped dramatically during the mid-1990’s, CNS elected to terminate the NRC license and submitted a request to DHEC for SNM disposal approval under License 097. The decrease in SMN shipments was primarily due to the decommissioning of facilities that once produced such wastes and SNM shipments’ being directed to another disposal facility. On June 9, 1997, DHEC amended License 097 to include SNM waste disposal. With the inclusion of SNM in License 097, the NRC license was terminated. Current unburied possession limits for U-235 and U-233 wastes are 350 grams and 200 grams, respectively.

Decommissioning Trust Agreement of 1981: On March 24, 1981, CNS entered into a Trust Agreement with the State of South Carolina to provide monies for establishment of a decommissioning fund. This fund must contain sufficient monies to decommission and stabilize the site in accordance with the requirements of the Closure Plan. In 1981, at the time CNS entered into the Trust Agreement, CNS contributed a lump sum of approximately $1.7 million to the decommissioning fund. No additional contributions were made until April 1, 1993, when $4.11 per cubic foot of waste disposed at the Barnwell site was contributed to the fund. This contribution lasted for three months. Contributions were again reinstated effective January 1, 1994, at $12.60 per cubic foot to cover costs of enhanced capping at the Barnwell site. On July 1, 1995, the contribution was reduced to the current $4.20 per cubic foot. CNS evaluates the adequacy of fund balance during each Closure Plan update.

2.2 Regulatory/Political History

During the early 1970's, the Barnwell site was one of six commercially operated disposal sites. By 1979, three of the commercial sites (in Illinois, Kentucky and New York) had closed, and the Barnwell site was receiving more than three-fourths of the nation's waste.

The increased rate of waste receipt led to South Carolina establishing limits on the annual volume of waste allowed to be received at the site. The volume restriction program gradually reduced allowable volume by one-half over a two-year period (1979-1981) to 1.2 million cubic feet per year. This restriction remained in effect until June 2000 with the enactment of the Atlantic Interstate Low-Level Radioactive Waste Compact Implementation Act (S1129), which established the current limits on volume.

During 1979, South Carolina developed and promulgated Regulation Number 61-83, "Transportation of Radioactive Materials Into and Through the State of South Carolina." This regulation established a permit system for waste generators shipping LLRW in the State, and a prior notification system to provide DHEC and CNS advance notification of shipments passing through the State and arriving at the site. The system requires that shippers certify that shipments have been inspected and meet the requirements of appropriate regulations and license conditions.

In 1980, the U.S. Congress passed the Low-Level Radioactive Waste Policy Act. The Act established three major policies. First, that each state is responsible for the low-level waste generated within its boundaries. Second, states may form compacts (or groups of states) to facilitate managing low-level waste generated within the boundaries of the compact states, including the right to deny disposal of out-of-compact wastes at compact disposal facilities. The Act also established the policy that these compacts could not refuse waste from other states until the U.S. Congress had ratified the compact. The Southeast Compact, consisting of eight southeastern states (Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Tennessee and Virginia) was formed, with the Barnwell site designated the regional facility.

In December 1982, NRC promulgated 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Wastes," which became effective in December 1983. This regulation specifies technical requirements applicable to the different phases of a disposal facility: licensing, operations, closure, post-closure surveillance and institutional control. As a matter of Agreement State compatibility, DHEC adopted 10 CFR Part 61 – equivalent regulations.

On January 1, 1986, the Low-Level Radioactive Waste Policy Amendments Act was signed into law, making a generator's continued access to the three operating disposal sites contingent on its compact meeting specified milestones for new site development. The amended Act clarified Congress' intent to require compacts (or individual states not within a compact) to provide disposal capacity for LLRW generated within their boundaries by January 1, 1993. The legislation also defined the LLRW for which states are responsible. It mandated Federal responsibility for all waste for which states are not responsible above NRC 10 CFR Part 61 Class C limits. The amended Act also established conditions for access to operating disposal sites during the interim period, allowed the partial rebate of surcharges to states and compacts which meet statutory milestones and established penalties for states that fail to meet the mandated site development goals. A US Supreme Court decision in 1992 struck down the penalty portion of the amended Act.

The South Carolina General Assembly (SCGA), in its 1992 session, enacted legislation to allow the Barnwell site to continue as the regional facility until December 31, 1995 subject to several conditions. One condition required states outside the Southeast Compact demonstrate progress in developing their own regional disposal sites in order to retain access to the Barnwell facility during an 18-month period (January 1993 through June 1994). After June 30, 1994, the Barnwell facility would accept only waste from Southeast Compact generators. By 1995, continued delays in building a new regional disposal site led South Carolina's governor to propose legislation to withdraw the state from the Southeast Compact.

In June of 1995, the SCGA enacted the legistation, South Carolina withdrew from the Southeast Compact, and the Barnwell facility began accepting waste from generators in all states except North Carolina and the Northwest Compact. North Carolina was restricted from site use due to its failure to develop the next disposal facility. The Northwest Compact states disposed of their LLRW at a facility in Washington. South Carolina also imposed a $235 per cubic foot tax on all waste received for disposal at the Barnwell facility. Proceeds from this tax went to the Children's Education Endowment Fund and have been used for educational scholarships and school construction.

Effective July 1, 2000, S1129 enabled South Carolina to join the Atlantic Compact (formerly the Northeast Compact). Provisions in the legislation limit waste volumes on a yearly basis, repeals the tax, and after eight years restricts acceptance of waste to three states: South Carolina, Connecticut, and New Jersey.

2.3 Licensed Disposal Area

The initial licensed area consisted of approximately 17.2 acres purchased by CNS as part of a larger tract. In April 1971, this tract was deeded to the Budget and Control Board, which leased this acreage back to CNS for disposal operations. This tract of land was part of a larger property evaluated and found suitable for use as a disposal site during the site's licensing phase (1969 to 1971).

The Lease Agreement was amended in 1976, enlarging the licensed disposal area to the current 235 acres. CNS Drawing #B-500-D-300 shows the 235 acre disposal area boundary, trench locations, ancillary facilities and fence lines.

2.4 Trench Construction and Maintenance

Amendment No. 3 to License 097 issued April 1971 was the original document permitting burial at the Barnwell site. This section summarizes the history of changes in trench design and construction and significant maintenance actions.

2.4.1 Trench Construction

1971 to 1983: As specified in Amendment 3, the first trenches were shallow earthen excavations. The waste was placed into these excavations surrounded and covered with backfill material, then capped with clay. The clay cap was covered with a sheet of 10-mil plastic, over which additional protective soil was placed. Trench excavations were required to be located above the water table.

Amendment 5 (April 1973) established several new trench design requirements, including standard trench dimensions. This amendment also required that a gravel-filled drain (French drain) be placed in the bottom center of the trench, running the length of the trench. Monitoring pipes located at specific intervals were placed in the French drain. Trench floor sand, surrounding and covering the French drain, was also incorporated into the trench design. The trench cover was reduced in thickness and no longer included 10-mil plastic.

Amendment 12 (December 1975) established design criteria for the slit trench. The new slit trench was like other trenches except width was greatly reduced. This trench was designed to provide a disposal method for higher activity waste such as irradiated reactor hardware. Amendment 12 also required placing the French drain and monitoring standpipes along the sidewall of the trenches to reduce the possibility of pipe damage during waste placement.

Amendment 15 (July, 1977) allowed larger trenches to be constructed. The larger trench size allowed CNS to arrange waste more efficiently to make better use of trench space and to reduce personnel exposure by using low-activity waste as shielding. This amendment also changed cover design, requiring a minimum thickness of clay and general earth cover.

1983 to 1996: At the end of 1982, NRC regulation 10 CFR 61 was promulgated. Amendment 36 facilitated the implementation of 10 CFR 61 at the Barnwell site by requiring segregation of wastes according to waste class. Amendment 36 describes the use of three separate trench designs to segregate wastes. The new trench designations were Class A, slit trench (C-type), and B/C waste trench.

In 1988, CNS improved the design of the trench floor French drain system based on an evaluation of the existing system and trench drainage properties. CNS changed trench standpipes and screens from polyvinyl chloride (PVC) to stainless steel and the French drain gravel materials to a coarse sand. The steel pipe provides greater resistance to collapse and bending during trench disposal and backfilling operations, and the sand minimizes the infiltration of fines into the French drain.

Amendment 45 (January 1990) required that CNS place polyethylene high integrity containers (HICs) containing Class B or C wastes in concrete vaults. This change was made to resolve concerns regarding the long-term stability of the polyethylene HICs.

In 1991, CNS changed cap design to reduce the likelihood and size of subsidence features on CNS trench caps.

During 1993, CNS began placing slit trench wastes in concrete vaults, eliminating the need for a concrete intrusion barrier on subsequent slit trenches.

1995 to Present: Amendment 46 (August 1995) required several substantial changes to trench design and construction. These changes included placing all waste in concrete vaults (unless otherwise approved by DHEC), incorporating an infiltrate detection and monitoring system (IDMS) in the Class A trench, covering all future trenches with enhanced multi-layer earthen cap and allowing phased trench construction.

Waste placement in vaults was implemented to improve long-term trench stability. The IDMS was designed and incorporated into Class A trench designs to provide a means for evaluating enhanced cover performance and collecting trench water. Enhanced trench caps, which had been installed on several trench areas prior to this amendment, were now required on all Barnwell site trenches. This amendment also allowed larger Class A trenches constructed, if appropriate, in phases to minimize surface water management and trench exposure to weather. This change allowed more efficient use of available area at the disposal site.

2.4.2 Trench Maintenance Actions

In addition to on-going routine disposal site and trench maintenance (see Section 3.2.3), CNS has implemented several significant maintenance and remedial actions affecting disposal trenches at the Barnwell site. These activities are summarized below.

The first significant trench maintenance activity at the Barnwell Site occurred during 1978 and 1979. It involved grading to improve drainage over several trenches. In 1987, the caps of several trenches were upgraded to remove native sand found adjacent to these trenches. Topsoil and surface sand around the perimeter of these trenches were excavated to native clay. Clay soils were then added and compacted to form a continuous clay cap over the entire area and buffer around the perimeter of these trenches. Topsoil was then replaced and the area seeded and fertilized. These activities were performed to decrease infiltration of surface water, limit erosion and achieve final closure elevations in this area.

During 1992, CNS completed the first cap enhancement on the Barnwell site in the southern trench area, a 12.5 acre area on the south end of the disposal site (shown as Phase 1 cap enhancement on CNS drawing B-500-D-300). Cap enhancement involved regrading existing trench covers to improve drainage, recompacting clay soils, and adding synthetic barrier materials (polyethylene and bentonite mat), sand drainage materials, and general earth cover (see section 6.2.1 for further details). The purpose of installing enhanced covers was to further reduce infiltration to the waste in early disposal trenches.

Between 1993 and 1998, CNS completed four other enhanced cap projects, covering another 68 acres of Barnwell site disposal trenches.

2.5 Waste Characteristics and Packaging

Over the years, the Barnwell site has disposed of numerous types and quantities of radioactive wastes. This section briefly highlights the predominant waste forms and their effect on site disposal.

2.5.1 Solidified Waste

Since the beginning of site operations, CNS has buried solidified liquid at the Barnwell site. Liquid wastes cannot be shipped to or buried at the site. It is the waste generator’s responsibility to ensure that all such wastes are properly solidified prior to shipment. Solidification methods have varied from the early use of absorbent material, such as vermiculite, to the present method of using approved solidification media such as cement.

2.5.2 Scintillation Materials

Scintillation materials, mostly in the form of liquid scintillation vials, were acceptable for burial at the site until May 1979. These wastes were packaged with absorbent materials and in some cases doubly-contained in steel drums. In 1979, receipt of this material was prohibited, because of the chemicals involved (toluene, xylene, benzene) and their potential to migrate from the trench. Several non-hazardous scintillation products have been approved by DHEC for disposal at the Barnwell site provided they are properly solidified and packaged.

2.5.3 Calcium Fluoride

From 1979 through 1981, the site received approximately 851,000 cubic feet of calcium fluoride containing low concentrations of uranium. Most of this waste was disposed in Trench No. 34. No other waste types were placed in this trench. Trench No. 30, designated for the receipt of institutional waste, received some of the calcium fluoride. However, a clay barrier running the width of the trench separated the calcium fluoride from other waste forms.

2.5.4 Dry Active Waste

Dry active waste (DAW) is material that has become contaminated with radioactivity, including paper, plastic, rubble, scrap metal, asbestos and soil. DAW is received for disposal in strong-tight steel or wooden containers. This waste form makes up the majority of the Class A waste volume. Most of the DAW currently being received has been compacted to reduce volume.

2.5.5 High Integrity Containers

Stabilization of certain waste forms through the use of high integrity containers (HIC) began in 1981. DHEC was the first regulatory agency to review and approve such containers. The material composition of the HICs ranges from high-density polyethylene to special non-corrosive metals.

In December 1989, NRC notified CNS that then-current polyethylene HIC designs did not meet long-term structural stability requirements. CNS developed a concrete disposal vault designed to meet structural requirements and received DHEC approval for its use in conjunction with the disposal of polyethylene HICs. In addition, the disposal vaults were approved as engineered intruder barriers. This allowed the disposal of Class C waste without the required five meters of overburden.

Polyethylene HICs containing Class B or Class C wastes have been placed in these disposal vaults since 1990. All Class B and Class C wastes regardless of their waste forms or container types have been disposed in concrete vaults since July 1993. Effective January 1, 1996, DHEC required all wastes regardless of waste class to be placed in disposal vaults. However, DHEC has allowed some exceptions, such as large-component wastes (i.e. steam generators), provided they meet the site's stability requirements.

2.5.6 Incinerator Ash

A portion of the DAW received for disposal is incinerator ash. Incinerator ash wastes must be rendered non-dispersible prior to shipment. Rendering it non-dispersible reduces the possibility that radioactive materials will be dispersed should a transportation or site-operation handling mishap occur. Methods for rendering ash non-dispersible include solidification, placement in a HIC and mixing with a binding matrix or double packaging. The volume of this waste form has increased significantly over the past few years, because higher disposal costs have made incineration cost-effective.

2.5.7 Filter Materials

Ion-exchange resins and filter media from nuclear plant generators have also accounted for a significant percentage of site disposal. Before receipt, these materials must be dewatered and placed in approved HICs or solidified.

2.5.8 Irradiated Hardware

Irradiated hardware is comprised mostly of metal components that have been subjected to neutron bombardment inside a nuclear reactor. The components may include control rod blades, shroud head bolts, non-fuel reactor components, etc. Irradiated hardware comprises a small percentage of the total volume disposed at the site. Most of these shipments are Class C waste and are buried in a slit trench. Concrete vaults have been used in the slit trench for the disposal of this waste since July 1993.

2.5.9 Sealed Sources

Sealed sources account for a small percentage of the overall volume disposed at the site. Although these sources are typically received in their original source holders, only the size of the source is considered during the waste classification. Therefore, the sources may exceed Class C limits. In 1989, CNS received DHEC concurrence to evaluate the acceptance for disposal of sealed sources containing Table II radionuclides, provided each source was less than 10 curies and encapsulated in a minimum of 4 inches of cement (Tables I and II radionuclides are provided in License 097). The cement must have a minimum compressive strength of 2500 pounds per square inch.

In 1993, DHEC expanded the approval process to allow CNS to evaluate the acceptance of non-transuranic sealed sources from Table I radionuclides, provided the source is less than the following specified limits:

^{14}C 100µCi	^{59}Ni 100µCi
^{63}Ni 0.1µCi	^{99}Tc 10µCi
^{129}I 0.1µCi	

Sources with radionuclides other than Radium, and transuranics with specific activities that do not exceed Class A limits, assuming a source volume of one cubic centimeter, may be disposed as Class A waste packaged as dry active waste.

2.5.10 Large Component Wastes

Large component wastes are usually large, heavy items shipped from commercial nuclear plants. Such items include steam generators, reactor pressure vessels, etc., that are shipped to the disposal site by combinations of barge, railway, and special over-the-highway transport equipment. Disposal of such components is a significant project that usually takes years of planning and often requires review and approval from both state and federal agencies. Through December 31, 1998, large components disposed by utilities include 13 steam generators, two reactor pressure vessels, and one pressurizer. One barge used by the US Navy to process radioactive waste has also been disposed.

2.6 Site Inventory Summary

A selected twenty radionuclides account for over 90 percent of the site's current radioactivity inventory. This list of radionuclides and radioactivity was originally provided by DHEC in August 1982. Since that time, CNS has updated monthly the quantities of these radionuclides received and amount decayed. Table 2-1 is a current (decay-corrected) inventory of these selected twenty radionuclides buried at Barnwell as of December 31, 1999.

In December 1982, NRC implemented 10 CFR 61, which required waste generators to provide a more detailed characterization of the radioactivity in their wastes. The regulation required that specific radionuclides used in the classification system and their activities be recorded on the disposal manifest.

The site's radionuclide inventory for waste received following implementation of 10 CFR Part 61 is provided in Table 2-2. This table provides a list of radionuclides and the quantity (in curies) of each received (not decay-corrected) during the period January 1, 1983 through December 31, 1999. It consists of the 10 CFR Part 61 classification table radionuclides and other short- (< 5-yr. half-life) and long-lived radionuclides not considered important in waste classification.

The annual volume of waste buried at the Barnwell site has varied significantly over the years, from approximately 50,000 ft^3 in 1971 to approximately 2,445,000 ft^3 in 1980. The total volume of waste buried at the site through December 31, 1999 was 27,658.524.33 ft^3. Table 2-3 lists the total volume buried each year.

Table 2-1
Selected Twenty Radionuclides by Quantity

Radionuclide[1]	Activity (Curies)[2]
Cobalt-60	1,151,879.33
Iron-55	591,194.97
Cesium-137	293,433.54
Hydrogen-3	367,825.73
Nickel-63	248,049.98
Manganese-54	8,131.82
Strontium-90	12,275.73
Cesium-134	7,318.03
Zinc-65	2,182.57
Chromium-51	13.27
Uranium-238	5,184.12
Krypton-85	763.91
Cobalt-58	761.39
Cerium-144	42.84
Zirconium-95	3.42
Iron-59	14.48
Strontium-89	1.53
Iodine-125	0.42
Cerium-141	0.17
Ruthenium-103	0.02
Total	2,689,077.27

(1) Selected isotopes.
(2) Current radioactivity as of December 31, 1999

Table 2-2
Radionuclides Received at Barnwell
(January 1, 1983 – December 31, 1999)

10 CFR Part 61 Nuclides	
Radionuclides	*Activity (Curies)*
Cobalt-60	2,752,048.98
Hydrogen-3	468,330.54
Nickel-63	265,404.33
Cesium-137	106,938.12
Strontium-90	11,674.56
Carbon-14	2,410.63
Nickel-59	2,039.61
Plutonium-241	438.87
Technetium-99	88.75
Curium-242	59.69
Transuranics (Alpha emitters with half-lives greater than 5 years)	47.40
Niobium-94	13.51
Iodine-129	9.10
Other Nuclides	
Nuclides with less than 5 year half-life	3,522,088.18
Actinium – 227	0.006
Aluminum – 26	.001
Barium – 133	7.63
Bismuth – 207	24.12
Cadmium – 113m	85.50
Cesium – 135	2.94
Chlorine –36	1.32
Chlorine – 38	.12
Depleted Uranium	2,499.70
Europium – 152	2.13
Europium – 154	4.26
Krypton – 85	378.66
Lead – 210	.47
Molybdenum –93	126.70
Niobium – 93m	.03
Potassium –40	1.6
Promethium – 145	.0008
Protactinium – 231	0.018
Radium – 226	22.28
Radium – 228	48.64
Rhenium – 187	.01
Samarium – 151	1.36
Silver – 108m	4.73
Technetium – 97	.002
Technetium – 98	.0003
Thorium – 230	5.04
Thorium – 232	2,129.65
Uranium – 232	.30
Uranium – 233	1.12
Uranium – 234	31.95
Uranium – 235	13.20
Uranium – 236	.26
Uranium – 238	1,942.29
Zirconium – 93	.58
Total	**7,138,928**

Table 2-3
Barnwell Burial Volumes

Year	Volume (cubic feet)
1971	50,219.34
1972	159,933.47
1973	599,886.28
1974	624,759.55
1975	643,564.44
1976	1,393,587.55
1977	1,636,425.12
1978	2,220,519.72
1979	2,238,322.13
1980	2,444,810.72
1981	1,543,278.67
1982	1,228,200.83
1983	1,240,668.21
1984	1,231,715.28
1985	1,214,422.99
1986	1,053,791.68
1987	958,275.82
1988	931,974.01
1989	1,103,299.56
1990	788,031.90
1991	789,681.85
1992	828,727.84
1993	605,443.07
1994	733,896.31
1995	484,890.82
1996	325,815.32
1997	222,269.48
1998	195,684.08
1999	166,435.79
Total	27,658,524.33

2.6.1 Waste Form/Packaging Requirements History

Since waste disposal at the site began in the early 1970's, many changes have occurred affecting the acceptability of wastes, waste packaging and methods for disposal. This section describes the history of waste types received and disposal methods.

Typical waste types disposed in the first years of operations were utility wastes consisting of dewatered resins, absorbed liquids and DAW. Institutional and industrial wastes were received in the form of biological materials, absorbed liquids, liquid scintillation vials surrounded with absorbent material (vermiculite), general laboratory trash, DAW, source and SNM materials. These wastes were generally packaged in metal drums, wooden or metal boxes (mostly wooden) and steel liners. A considerable amount of biological waste containing mostly H-3 and C-14 was packaged in paper containers.

In April 1974, DHEC prohibited the receipt of utility-generated liquids processed in absorbent materials. These liquids had to be processed by cement solidification.

In July 1977, the license was amended to broaden the list of acceptable solidification media. These included cement (already being used), urea formaldehyde, DOW® ion exchange media, Delaware Custom media (solidification) and asphalt. Absorbed institutional liquids and scintillation vials continued to be accepted as previously discussed; however, most of these wastes were disposed in separate trenches.

In May 1979, hazardous scintillation liquids were prohibited from site disposal. Also, institutional liquids had to be solidified.

In July 1981, a significant change in the radioactive material license occurred. The change required all ion-exchange resin and filter media bearing isotopes having half lives greater than 5 years, and having a combined activity of one microcurie per cubic centimeter, to be solidified or placed in a DHEC-approved HIC. Solidification products were DOW® media, cement, urea formaldehyde, asphalt and Delaware Custom media. Urea formaldehyde was discontinued as an acceptable solidification medium in September 1981. Biological wastes were required to be double-packaged in metal containers with absorbent material and lime added to the waste and the interstitial space between containers filled with absorbent materials.

The operational requirements of 10 CFR Part 61 were implemented at the site during 1982. This required certain waste, based on specific radionuclides and concentrations, to be processed/packaged in a more stable form. Since most of these wastes were already packaged in HICs, the biggest effect was the requirement to segregate waste into separate trenches based on waste class.

In 1989, NRC concluded that the current design of polyethylene HICs did not meet long-term stability requirements. A concrete vault was approved by DHEC to allow continued acceptance and disposal of Class B and C waste within the polyethylene HICs.

Since 1996, CNS has buried all waste in DHEC-approved vaults. These vaults are designed to provide structural integrity to all waste packages. Large waste components may be disposed without vaults with DHEC concurrence.

2.6.2 Radionuclide Reporting History

Wastes received for disposal are documented on shipment/disposal manifests. The manifest has evolved during the site's history to meet regulatory requirements and site reporting needs. During the early years of disposal, the manifest did not require specific radionuclide information. Often, only the single most abundant radionuclide or a small percentage of the nuclides were listed. During the late 1970's and early 1980's, radionuclide reporting improved as a result of regulatory reporting changes. Isotopes such as C-14, H-3, etc., (usually shipped by private industries and universities) were specifically listed on the manifests enabling their existence and quantities to be traced back to their origin. However, in the case of power plant generated wastes, nuclide reporting was still limited mainly to the more abundant nuclides such as easily identified gamma emitters.

With the full implementation of 10 CFR Part 61 in 1983, radionuclide reporting vastly improved to meet waste stabilization and classification requirements. Specific waste stream samples from power plants were analyzed for hard-to-identify radionuclides by independent labs. Scaling factors were also developed to better estimate radionuclides in waste streams.

2.6.3 Estimation of Long-Lived Inventory

CNS evaluated the need to estimate the quantity of radionuclides that may not have been included in earlier waste manifests. The conclusions of that evaluation are summarized below:

- CNS can only produce an estimate of radionuclide inventory because reconstruction requires professional judgment and assumptions.
- CNS estimated the quantity of long-lived radionuclides that may be disposed at the Barnwell site. CNS found that these estimations of radionuclide inventory compare favorably with independent sources of radionuclide inventory data.

3.0 OPERATIONAL SUMMARY

The following section describes the current practices associated with disposal site operations, including activities related to meeting performance objectives, waste forms and classification, regulatory oversight, disposal trenches, ancillary facilities, surface water management and environmental monitoring programs.

3.1 Regulatory Requirements

The disposal of low-level radioactive waste at the Barnwell site is governed by the requirements of License 097. The license provides the requirements for operating, closing, and maintaining a disposal facility in compliance with DHEC regulation 61-63, "Radioactive Materials" (Title A). Title A incorporates the requirements of NRC regulation 10 CFR Part 61 (Licensing Requirements for Land Disposal of Radioactive Wastes) and 10 CFR Part 20 (Standards for Protection against Radiation). Radioactive material disposal requirements are discussed below. (CNS also complies with all other applicable federal [OSHA, EPA, etc.] and state regulations).

3.1.1 Performance Objectives

In December 1982, NRC promulgated 10 CFR Part 61, "Licensing Requirements For Land Disposal of Radioactive Wastes," which became effective in December 1983. These requirements have been incorporated into License 097 as well as into DHEC Regulation 61-63 (Title A). Part 61 specifies the basic requirements for land disposal of low-level radioactive waste, including disposal facility licensing, operation, closure, post-closure, and institutional control phases. This regulation emphasizes waste and disposal site stability and the goal of limiting access to waste. It established a waste classification system, consisting of three waste classes with associated radionuclide concentration limits. Some of the key requirements of Part 61 as embodied in the specific performance objectives in Subpart C of the regulation are described below.

The performance objectives have been established to protect the public from releases of radioactivity, to protect individuals during operations, to ensure stability of the disposal site after closure, and to protect individuals from inadvertent intrusion into the waste after active institutional controls are terminated. The time frame for maintaining controls over waste buried in a Part 61 site is 500 years.

The performance objectives require that every reasonable effort be made to maintain radiation exposures as low as reasonably achievable. Operations must be conducted in compliance with the standards for radiation protection in 10 CFR Part 20, the requirements of which are incorporated in DHEC Regulation 61-63, Title A.

Radioactive material releases to the environment in groundwater, surface water, air, soil, plants or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, or 25 millirems to any other organ of the body for any member of the public.

The disposal facility must be sited, designed, used, operated, and closed in such a manner as to achieve long-term stability and to eliminate, to the extent practicable, the need for ongoing active maintenance following closure so that only surveillance, monitoring, or minor custodial care are required.

Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.

3.1.2 Waste Form and Classification

Waste form and classification are the primary factors affecting waste acceptance and disposal at the Barnwell site. Waste class is determined by evaluating the types and concentrations of long- and short-lived radionuclides in a waste and applying the specific requirements in SC Regulation 61-63 (Title A). Waste form also affects method and location of disposal. Stable waste forms provide, in and of themselves, isolation and confinement of the radioactive material. Unstable waste forms are those for which radioactive material confinement is provided primarily by the geohydrologic features of the burial environment. Waste classification, form, and disposal criteria are described further below.

Class A wastes contain the lowest concentrations of radioactivity and are not required to be structurally stable for burial. Class B wastes contain higher concentrations of radioactivity and must meet rigorous requirements on waste form to ensure stability after closure.

Class A and B wastes can be buried without special provision for intrusion protection because they contain types and quantities of radioisotopes that will decay during the 100-year institutional control period and therefore do not pose an appreciable hazard to an intruder.

Class C wastes contain long-lived radionuclides and high concentrations of radioactivity. These wastes must meet the physical form requirements of Class A, the stability requirements of Class B, and must be protected against inadvertent intrusion.

Class C wastes must be disposed so waste is at least five meters below land surface or disposal must incorporate intruder barriers that are designed to protect against inadvertent intrusion for a least 500 years.

3.1.3 Regulatory Oversight

CNS operates its disposal facility in accordance with License 097 issued by DHEC. To ensure compliance with the facility license, DHEC routinely inspects facility operations. A full-time DHEC official stationed at Barnwell inspects incoming shipments and burial operations on a daily basis. DHEC engineers visit the site weekly to inspect trenches and site conditions. Also, periodic unannounced inspections are made by DHEC officials typically to audit facility records for compliance with license and other applicable regulatory requirements.

DHEC also inspects and approves each trench before CNS begins burial operations. Final trench approval is based on several DHEC inspections performed during trench construction. DHEC also reviews and approves trench designs, trench construction and other facility procedures, and special waste types for burial.

In the area of radioactive material transportation, the U.S. DOT and DHEC have the authority to inspect waste shipments upon arrival at the Barnwell site to ensure compliance with federal shipping regulations.

To ensure compliance with regulatory requirements and continued success during regulatory and other external audits, CNS maintains an internal audit program. The results of internal audits are made available for regulatory review.

3.2 Disposal Trenches

Current Barnwell site trench design and construction practices are governed by a DHEC-approved trench construction procedure and trench construction details drawings for each trench type. According to License 097, changes to these documents must be approved by DHEC prior to implementation. Trench areas are qualified for use prior to trench construction in accordance with a CNS-approved procedure.

3.2.1 Disposal Trench Qualification

Trench areas are qualified for use prior to trench construction. A geotechnical and hydrological trench qualification investigation is performed in the proposed trench area to demonstrate satisfactory soil characteristics and water table conditions, and suitable proposed trench design.

Site conditions (surface drainage, access) and information from existing boreholes are evaluated as the initial phase of field investigation. Additional exploratory boreholes are drilled if available information is insufficient to characterize the geology of the proposed trench area.

Nearby water table wells are used to determine maximum historic water levels in the area. These data are used to establish the maximum trench depth.

CNS combines trench data and evaluations along with the proposed trench design drawings into a trench qualification report, which is submitted to DHEC for review and approval. Construction begins after DHEC approval. CNS and DHEC verify conformance to design by inspections at designated hold-points in accordance with the trench construction procedure.

3.2.2 Current Trench Designs

Disposal trenches are constructed in accordance with the approved construction procedure, the appropriate trench construction detail drawing and the specific proposed trench design drawing. The drawings are approved by DHEC prior to use. The construction process is controlled through a series of documented hold points and inspections. CNS typically uses earthmoving contractors to construct Class A and Class B/C trenches and CNS personnel and equipment to construct slit trenches.

Prior to excavation, a Registered Land Surveyor (RLS) lays out the trench boundaries in accordance with the approved proposed trench drawing. The larger Class A and Class B/C trenches are constructed using a combination of hydraulic excavators, dump trucks, motor graders and tractor scrapers. During construction, temporary trench ramps are used to provide access to the excavation area. Slit trenches, due to their narrow and steep-walled design are excavated entirely from the top. CNS allows no personnel entry into the slit trench excavation during construction or trench operations. CNS excavates slit trenches using a hydraulic excavator and dump trucks. CNS extends the trench, as needed, based on waste receipt projections, thereby minimizing trench exposure to rainfall, runoff, and other forms of weathering.

As excavation proceeds in all trench types, the RLS monitors elevations and sloping and establishes trench bottom elevations. Disposal trenches include systems for collection and removal of water entering the closed trench.

CNS conducts formal and informal inspections throughout the construction process and DHEC performs up to three formal inspections.

Formal DHEC inspections occur after (1) trench excavation, (2) drain construction, and (3) final floor sand installation. After final trench approval, CNS prepares an as-built trench drawing and documentation package. Pertinent documents are maintained as permanent trench construction records.

3.2.3 Site Maintenance

As required by License 097, CNS implements a comprehensive site inspection and maintenance program to ensure trench cap integrity and to maintain proper surface water drainage. All completed trenches are inspected monthly and after substantial rainfall. General disposal site inspections occur weekly. The inspections identify concerns such as erosion, settlement, and water ponding on or around trench areas and ensure timely repair.

CNS maintains records of inspections and maintenance actions. These records document disposal area performance and provide data for estimating future trench maintenance requirements.

CNS manages surface water in accordance with the requirements of License 097 and State NPDES regulations. The primary requirements of License 097 are to eliminate run-in of surface water into open trenches, efficiently drain rainwater off of closed trench caps to minimize potential infiltration, and contour trench covers to minimize erosion. These considerations are addressed in the trench construction procedure and by final cover design, both of which are approved by DHEC before implementation. NPDES requirements are implemented through a Storm Water Pollution Prevention Plan (SWPPP). The purpose of the SWPPP is to establish measures to minimize the release of pollutants (including sediment) from the disposal site in storm water.

3.3 Site Ancillary Facilities

CNS maintains several facilities on and adjacent to the Barnwell site, some directly supporting site operations and others related to parent company business lines. Table 3-1 lists existing facilities supporting the disposal operation, their current use, and location. All buildings on CNS owned and CNS leased property, immediately adjacent to the site, are described further below.

The Nuclear Services Clean Shop provides space and facilities for testing and repair of non-contaminated CNS waste processing equipment. It is also used for machining, welding and performing electrical repairs in general support of the Barnwell complex.

Receiving Warehouse No. 2 is the point of receipt and inspection for shipments of materials and supplies to the disposal site and other facilities in the Barnwell complex. Goods are inventoried and stored here until needed and certain routine supplies are kept and dispositioned from this location.

Warehouse No. 3 is primarily used for storage of materials and supplies associated with Nuclear Plant Services activities, such as ion-exchange media and waste processing equipment. However, CNS also uses the facility as a geological core storage area, in support of disposal site characterization.

The Administration Building houses most of the site administrative staff including Site Management, Security, Personnel, Finance, and Regulatory Affairs. The main access gate is adjacent to the building and controlled by Security whose office overlooks the gate. The Administration Building is on CNS property, but the roadway and access gate are on leased state property.

The Transportation Maintenance Shop and its grounds are owned by CNS and leased to Hittman Transport, Inc. The shop is used for the maintenance of their transportation fleet including tractors, trailers and casks, and includes office space for the Hittman administrative staff. The shop includes three repair/inspection bays, one welding bay, one painting bay, and a parts storage area. Hittman provides transportation services to customers of the Barnwell site.

The Environmental and Dosimetry Laboratory (BEDL) contains facilities and equipment for radiological analysis of air, water, and soil samples collected as part of the Barnwell site environmental monitoring program. The laboratory also provides company-wide radiological personnel monitoring services, such as whole body counting, bioassay, and dosimetry services. The laboratory's professional technical staff performs disposal site engineering design, environmental characterization, and site performance studies. Radioactive Material License 287-03 authorizes possession and use of radioactive material in the analytical laboratory.

Table 3-1
CNS Barnwell Ancillary Facilities

Number(1)	Name	Location(2)	Use(3)
1	Nuclear Services Clean Shop	CN	CS
2	Receiving Warehouse No. 2	SP/RA	DA/CS
3	Warehouse No. 3	SP/RA	DA/CS
4	Administration Building	CN	DA/CS
5	Transportation Maintenance Shop	CN	CS
6	Environmental & Dosimetry Laboratory	CN	DA
7	Liner Operations Building	SP	CS
8	Site Building	SP/RA	DA
10	Health Physics Building	SP/RA	DA
11	Site Operations Maintenance Building	RA	DA
13	Cask Preservation Building	RA	DA/CS
14	Cask Maintenance Building	RA	DA
15	Field Services Maintenance Warehouse	RA	CS
16	Grounds Maintenance Shop	RA	DA
19	Drilling Equipment Storage Trailer	RA	DA
20	Instrument Calibration Shop	SP	DA/CS
21	Nuclear Services Support Facility	CN	CS
22	Scaffolding Storage Building	CN	CS

(1) Building numbers correspond to CNS Drawing B-500-D-300.

(2) The location codes indicate facility is on State Property (SP), CNS Property (CN), disposal site restricted area (RA), or bordering restricted area fence (SP/RA).

(3) The use codes indicate if facility supports disposal activities (DA), Nuclear Services (CS) or is shared with other company business lines (DA/CS).

In the Liner Operations Building, CNS receives, prepares, inspects, and stores liners and high integrity container (HICs). Liners and HICs are provided to CNS customers for use in processing and shipping waste. Although manufactured elsewhere, CNS customizes the liners and HICs for customers by manufacturing and installing internal structures (for de-watering projects), attaching lifting devices, and adding foam to HIC tops and bottoms, as required.

The Site Building is the personnel access and egress point for the disposal site controlled area. Security staff control vehicle and personnel access to the controlled area at this location. Monitoring equipment is provided for routine self-monitoring to detect personnel contamination. The Site Building also includes site employee lockers, a break room, and an office for the DHEC on-site inspector.

The Health Physics Building provides office space for health physics technicians to perform radiological surveys of waste transport vehicles and to evaluate waste manifests and other shipment documentation. The building also houses contamination smear counting equipment and meters used during vehicle surveys.

The Site Operations Maintenance Building provides facilities for preventive maintenance and repair of equipment used in the daily operations of the site, including a carpenter's shop.

The Cask Preservation Building contains temporary covered parking facilities for trailers and casks and for sand blasting equipment. A separate bay is provided for blasting surfaces with abrasives to reduce contamination (such as cask interiors) or to prepare surfaces for painting (such as cask exteriors). This bay is sealed and maintained under negative pressure during operations, with exhausts passing through High Efficiency Particulate Air (HEPA) filters before release.

The Cask Maintenance Building (CMB) is used to prepare casks for offloading (removing rain covers, loosening lid bolts, etc.), decreasing radiation exposure and improving efficiency and safety during offloading. Casks are also prepared here for release from the site.

The Field Services Maintenance Warehouse has been used for the storage and decontamination of contaminated field equipment primarily used in utility fuel pools. It contains a small, 12 foot deep simulated fuel pool for testing equipment and training personnel. This facility is currently not in use.

The Grounds Maintenance Shop, which is attached to the Cask Maintenance Building, provides storage space for disposal site grounds maintenance equipment and supplies.

The Drilling Equipment Storage Trailer contains parts and supplies in support of drilling operations and environmental sampling at the disposal site.

The Instrument Calibration Shop provides space for calibration of health physics equipment. It also houses instrument calibration sources. Radioactive Material License 287-01 authorizes possession and use of radioactive material in the calibration source area.

The Nuclear Services Support Facility provides space and facilities for testing, repairs and decontamination of CNS waste processing equipment. This building also houses specialized equipment for decontamination of scaffolding used at nuclear facilities.

The Scaffolding Storage Building provides storage space for clean scaffolding after receipt, inspection and decontamination.

3.4 Environmental Monitoring

CNS manages both radiological and non-radiological monitoring programs for the Barnwell site. These programs are designed to assure that any releases of waste materials can be readily detected during operation of the site or following closure. The monitoring programs are designed to protect workers, the public, and the environment from harmful levels of radioactivity and other regulated chemicals. Monitoring programs include constant surveillance and research on all possible pathways for transport of radioactive and potential non-radioactive materials through environmental media. Non-radiological program requirements are based on 40 CFR 122.21, Appendix D, Tables II and III. The radiological monitoring program objectives incorporate International Commission on Radiological Protection (ICRP) guidelines. These objectives (from ICRP publication No. 43) are listed below.

The primary objectives of the radiological monitoring program are:

- To assess actual or potential doses to critical groups and populations from the presence of radioactive materials or radiation fields in the environment from normal operations or accidents. This may be limited to the assessment of dose equivalents to critical groups or may extend to the assessment of collective dose equivalents to populations.

- To demonstrate compliance with authorized limits and legal requirements.
- To check the condition of the source, the adequacy of operation of the site, or containment, and the effectiveness of effluent control, to provide a warning of unusual or unforeseen conditions and, where appropriate, trigger a special radiological monitoring program.

The secondary objectives of the monitoring program are:

- To disseminate monitoring information to the regulatory agencies.
- To maintain a continuing record of the effect of the installation or practice on pre-existing environmental radioactivity levels.
- To distinguish the contributions from the operator's installation or practice from contributions from other sources.
- To obtain data on the behavior of materials in the local environment that may be required in assessment of the consequences of accidents.
- To identify changes in the relative importance of transfer pathways and mechanisms including the emergence of new pathways, and hence, to enable the radiological monitoring program to be revised in light of experience and in response to changing conditions.
- To verify or refine the predictions of environmental models, in order to improve the structure of the model and to reduce uncertainties in the parameters.
- To conduct more general scientific studies aimed at improving knowledge about radionuclides in the environment.

CNS' program includes a careful record of background radioactivity and contributions from other sources, thorough analysis of results, continuous characterization of the site and the area surrounding the site to assure that assessments are realistic and on-going research to improve knowledge of radioactive materials in the environment.

3.4.1 Radiological Monitoring Program

CNS monitors the atmosphere, soil, vegetation, surface water, sediment, and groundwater. In addition, instruments are carefully located to check direct radiation from the site. Each of these areas is discussed briefly in the sections that follow.

Atmospheric Monitoring

CNS implements atmospheric monitoring around the perimeter of the disposal facility as well as around active disposal areas. Atmospheric monitoring is concentrated close to active disposal areas in order to increase the likelihood of detecting any potential release soon after it occurs. A particulate filter sample is taken at the side of the trench near the edge of the wall where the waste is being buried. This air particulate monitor is positioned downwind and moved whenever there is a shift in wind direction. Additional air sampling is performed on an as-needed basis.

Continuous air samples are taken at permanently located stations on the site boundary. Most nuclear facilities locate these stations based on meteorological data, with preference given to those sectors where the wind is directed at the highest frequency. However, consistent with ICRP guidance, Barnwell site air stations are located uniformly around the site. Uniform spacing enables CNS to distinguish between radioactive materials potentially released by the adjacent Savannah River Site nuclear reservation and the Barnwell site. The best method of assuring that all sectors are adequately monitored and that all precautions are taken to measure releases from other facilities is by locating air sampling stations uniformly around the site.

Boundary air stations are enclosed in an approximately 20-foot by 20-foot fenced area. The purpose of the protective fence is to guarantee an undisturbed plot of ground and vegetation free of fertilizers or other chemicals that may be used around the site to enhance the growth of grass and trees. Since fertilizers are frequently high in natural radioactivity, they could affect the ability to identify small changes in radioactivity.

Soil and Vegetation

Surface soil samples are taken to detect deposition and early infiltration of radioactive material into the soil. Characteristically, tritium and other soluble species have the potential to move through the top layer of the soil rapidly. Surface soil samples would provide detection of early or on-going deposition of such radionuclides. Insoluble species, which move much more slowly and are not readily distributed in soil, would tend to remain near-surface. In this case, samples help demonstrate if airborne radioactive material has been deposited as a result of routine site operation. Likewise, samples of vegetation may also indicate whether radioactive materials are being deposited. However, these samples may indicate that radionuclides are being taken up through the roots of plants.

Surface Water and Sediments

Surface water and sediments are collected at the Barnwell facility. Particular attention is given to surface waters outside the site boundary that could be used as drinking water by the public or animals. Downgradient of the disposal site, CNS has located and monitors where groundwater first emerges to join surface streams. At the Barnwell site, shallow groundwater discharges at the headwaters of Mary's Branch. Water and sediments are monitored at this location, as well as at three other stream locations in the vicinity.

Groundwater

The most important facet of any environmental monitoring program for a low-level radioactive waste site is groundwater. CNS strongly believes that a fundamental understanding of the geology and hydrology of the area is central to a successful environmental monitoring program.

Currently, an extensive network of both on- and off-site wells is monitored routinely for radioactive materials. On-site wells monitor groundwater near trench locations and at the site boundary. Off-site wells are located both up-and down-gradient from the site to as much as three miles away. Wells are strategically positioned in all directions to permit analysis of groundwater upgradient as well as downgradient of the site to determine baseline radiologic conditions.

Thermoluminescent Dosimeters

Each environmental station is equipped with a set of thermoluminescent dosimeters (TLDs) to measure external exposure from penetrating gamma radiation. These dosimeters are also located at intervals of approximately 300 feet along the perimeter of the site.

Current Program Summary

The sample collection schedules for the on- and off-site areas including number of each sample type, the frequency of sampling, and analyses performed are shown in Table 3-2.

CNS estimates that there are at least 30 private water wells within ½ mile of the disposal site boundary. Currently, nine of these water wells are monitored by CNS (Table 3-2).

Monitoring results are submitted to DHEC on a quarterly basis in the form of two reports, the CNS Site Operational Monitoring Report and the CNS Environmental Monitoring Report.

Table 3-2

Barnwell Site Monitoring Program Sample Collection Schedule

Sample Description	# of Loc(1)	Type	Media	Frequency	Analysis
On-Site Locations:					
Monitor Wells[2]	103	Grab	Water	Quarterly	Gross Alpha/Beta, Gamma Isotopic, Tritium, C-14[5], pH, Conductivity, Temperature
Observation Sumps[3]	129	Grab	Water	Quarterly	Gamma Isotopic & Tritium
External Gamma	26	Continuous	TLD	Quarterly	Exposure
Site Boundary Locations[1]:					
Wells[2]	28	Grab	Water	Quarterly	Gross Alpha/Beta, Gamma Isotopic, Tritium, C-14[6], pH, Conductivity, Temperature
Soil	11	Grab	Soil	Annually	Gamma Isotopic, Tritium
Vegetation	11	Grab	Vegetation	Annually	Gamma Isotopic, Tritium
Atmospheric	11	Continuous	Particulate Filter	Bi-Weekly	Gross Alpha/Beta, Gamma Isotopic
External Gamma	66	Continuous	TLD	Quarterly	Exposure
Off-Site Locations:					
Potable Wells[4]	9	Grab	Water	Annually	Gross Alpha/Beta, Gamma Isotopic, Tritium, pH, Conductivity, Temperature
Monitor Wells[2,4]	98	Grab	Water	Quarterly	Gross Alpha/Beta, Gamma Isotopic, Tritium, C-14[7], pH, Conductivity, Temperature
Surface Water[9]	8	Grab	Water	Quarterly	Gross Alpha/Beta, Gamma Isotopic, Tritium, C-14[8], pH, Conductivity, Temperature
Soil[9,10]	5	Grab	Soil	Annually	Gamma Isotopic, Tritium
Vegetation[9,10]	5	Grab	Vegetation	Annually	Gamma Isotopic, Tritium
Sediment[9]	4	Grab	Sediment	Annually	Gamma Isotopic, Tritium
Atmospheric[10]	1	Continuous	Particulate Filter	Bi-Weekly	Gross Alpha/Beta, Gamma Isotopic
External Gamma	13	Continuous	TLD	Quarterly	Exposure

[1] As of February 1999
[2] Water levels measured quarterly
[3] Water levels measured monthly
[4] Selected wells sampled quarterly
[5] At 15 wells annually, Gross-Alpha Beta is used as a surrogate for C-14
[6] At 3 wells annually, Gross-Alpha Beta is used as a surrogate for C-14
[7] At 10 wells annually, Gross-Alpha Beta is used as a surrogate for C-14
[8] At 2 locations annually, Gross-Alpha Beta is used as a surrogate for C-14
[9] Off-Site Springs and Creeks:
[10] Barnwell County Airport

3.4.2 Non-radiological Monitoring Program

CNS monitors nonradiological compounds in groundwater. The current nonradiological program is summarized in Table 3-3. Samples are collected by CNS and provided to an independent laboratory for analysis. Upon receipt of the laboratory results, CNS prepares a nonradiological monitoring report which presents results and data review. This report is sent to DHEC for information.

Table 3-3

Barnwell Site Non-Radiological Groundwater Sample Schedule

Sample Description	# of Locations	Type	Media	Collection Frequency	Analysis[1]
Wells	16	Grab	Groundwater	Quarterly	pH, Conductivity, Total Organic Carbon, Volatile Organics, Library Search
Stream	2	Grab	Surface water	Quarterly	pH, Conductivity, Total Organic Carbon, Volatile Organics, Library Search
Wells	12	Grab	Groundwater	Quarterly	pH, Conductivity, Total Organic Carbon, Chloroform
Wells	16	Grab	Groundwater	Annually	pH, Conductivity, Total Organic Carbon, Volatile Organics, Library Search, Acids, Base/Neutrals, Pesticides/PCB's, Cyanide, Phenols, Carbon-14
Stream	2	Grab	Surface water	Annually	pH, Conductivity, Total Organic Carbon, Volatile Organics, Library Search, Acids, Base/Neutrals, Pesticides/PCB’s, Cyanide, Phenols, Carbon-14
Wells	12	Grab	Groundwater	Annually	pH, Conductivity, Total Organic Carbon, Volatile Organics, Library Search

1. Volatile Organics, Metals, Acids, Base/Neutrals, Pesticides/PCB's, Cyanide, and Phenols selected based on lists given in EPA, 1992. Carbon-14 is collected annually at nonradiological monitoring points.

4.0 WASTE PROJECTION SUMMARY

Waste disposal and land use projections for the next ten years are summarized in this section. The purpose of this ten year period is to be consistent with the time frame required by S1129 for the Least Cost Operating Plan (CNS, 2000a). After eight years, CNS will begin in-region-only operations, which will be segregated from and implemented simultaneously with closure of other site areas. Closure for areas other than that needed for in-region-only operations will be completed during FY 2008/2009 and FY 2009/2010. CNS expects in-region-only operations to continue up to thirty years after the first eight years of operations at waste volumes comparable to the last two years of the ten-year period. During in-region-only operations, closed parts of the site will be maintained under the long-term care plan (see Section 8.0).

4.1 Waste Volume and Characteristics

Waste volume and characteristics are the primary factors involved in long-term disposal facility planning. These data directly affect disposal trench design, construction and closure schedules and disposal operations planning.

S1129 establishes limits on waste volume that can be received at the disposal site for the eight years of disposal operations between 2000 and 2008. For planning purposes, CNS assumes these volumes will be achieved in each fiscal year after FY 2000/2001. The last two years of the 10-year period differ in that waste may be received only from within the Atlantic Compact region. For the estimated 30-year in-region-only period, CNS estimates waste receipts at much lower volumes (as shown); recognizing that in later years volumes may increase to support decommissioning activities.

Table 4-1
Projected Radioactive Waste Volumes

Fiscal Year	Volume (Cubic Feet)	Number of Slit Trench Shipments
2000/2001	145,000	35
2001/2002	80,000	26
2002/2003	70,000	26
2003/2004	60,000	26
2004/2005	50,000	26
2005/2006	45,000	26
2006/2007	40,000	26
2007/2008	35,000	26
2008/2009	8,000	10
2009/2010	8,000	10

In Table 4-1, CNS has separately listed the projected number of high activity slit trench shipments. These shipments, although representing a small fraction of total waste volume, require significant manpower in preparation for and during offload. Slit trenches are small trenches for which the construction schedule is determined by the projected number of shipments rather than volume.

The volume due to large component shipments is included in the total volume in Table 4-1. Each large component disposal requires a significant level of effort in planning and preparation for disposal. Often, site and trench modifications must be prepared to facilitate access and disposal, and special approvals must be received from the appropriate regulatory agencies. A few large components may be a significant portion of any single year's projected volume.

4.2 Projected Trench Construction and Site Use

The projected volumes in Table 4-1 have been used along with recent data on waste characteristics to estimate trench construction requirements and land use for FY 2000/2001 through 2009/2010.

During the next ten years, CNS anticipates constructing twelve new slit trenches, one Class A trench and one B/C trench. The number of trenches needed is based on waste volume projections and the percent of that volume placed in each trench type.

To estimate the number of trenches required for the next ten years, CNS has used projected waste volumes and the average fraction of total waste volume placed into each trench type since 1998. CNS used 1998-2000 data, the most recent data available, because longer-term averages are unreliable given recent industry trends. Table 4-2 below summarizes actual percents of total disposal volume placed in each trench type for the past three calendar years. Disposal location depends on dose management considerations, waste separation requirements, and trench space availability. Projected slit trench usage is based on the number of shipments not volume.

Table 4-2
Waste Volume Buried by Trench (in ft^3)

	A Trench		B/C Trench		Slit Trench		Total Volume
	Volume	%	Volume	%	Volume	%	
1998	124,740	63.7%	69,805	35.7%	1,139	0.6%	195,684
1999	121,980	73.2%	42,945	25.8%	1,510	0.8%	166,435
2000 (Jan - June)	54,981	79.4%	13,331	19.3%	885	1.3%	69,197

Trench locations for the next ten years and beyond are shown on Drawing B-500-D-300. CNS has located trenches during the next eight years adjacent to existing trench areas to ensure efficient use of available disposal area and to minimize area requiring enhanced cap. After year eight, CNS will transition to segregated disposal operations, which will occur within the designated area on CNS drawing B-500-D-300. Table 4-3 identifies projected trench requirements by year. New trenches over the next ten years will occupy approximately four acres.

Table 4-3
Projected Trench Requirements

Fiscal Year	Trench[1]
2000 / 2001	Proposed Slit #1
2001 / 2002	Proposed Slit #2
2002 / 2003	Proposed Slit #3, Proposed Slit #4, Proposed B/C #1
2003 / 2004	Proposed Slit #5
2004 / 2005	Proposed Slit #6, Proposed Slit #7
2005 / 2006	Proposed Slit #8
2006 / 2007	Proposed Slit #9, Proposed Slit #10
2007 / 2008	Proposed Slit #11, Proposed A #1[2]
2008 / 2009	
2009 / 2010	Proposed Slit #12

[1] Proposed trenches are identified on CNS drawing B-500-D-300.
[2] Proposed A#1 will be sized for remaining waste during 2007/2010 and decommissioning waste.

4.3 Remaining Site Capacity

The Barnwell site is divided into different use categories, as shown on CNS Drawing B-500-D-300. The 235 acre licensed disposal area is divided into completed trenches, potential trench areas, and ancillary facility, water management and buffer zone areas (see Table 4-4).

Table 4-4
Barnwell Site Land Designations

Designation	Acreage
Licensed Disposal Area	235
Area Used for Disposal Since 1971	102.5
Future Trench Area	12.5
Other Leased Property (including buffer zone, water basins, ancillary operations, and other areas unsuitable for disposal)	120

As of January 1, 1999, CNS estimated remaining disposal site capacity at approximately 3.2 million cubic feet. CNS has submitted to DHEC regular reports and updates on remaining disposal capacity, including detailed reports in 1991, 1995, 1997 and 1999. Current remaining capacity is an estimate. Capacity may increase as CNS develops improvements in site design and burial practices, or may decrease if (1) the relative percent Class B/C trench waste continues to increase or (2) site areas are found to be unsuitable for disposal trenches.

5.0 ENVIRONMENTAL CHARACTERIZATION

This section summarizes CNS' current understanding of disposal site environmental conditions. Particular emphasis has been placed on describing and understanding the site's geology and hydrology because groundwater is the primary pathway for radionuclide migration to the general public.

5.1 Previous Environmental Assessments

On an ongoing basis during the lifetime of the Barnwell site, CNS, its contractors, and independent groups have studied the environmental characteristics of the Barnwell site. Several of the most significant evaluations are described below.

5.1.1 Environmental Assessments

Several comprehensive environmental assessments have been performed at the site, one of which was the "Environmental Assessment for Barnwell Low-Level Radioactive Waste Disposal Facility" (CNS, 1980), prepared and published by CNS in 1980 in response to a request from DHEC. This document is an assessment of expected and observed environmental and socioeconomic impacts from operation of the Barnwell site.

A second assessment was conducted by the NRC in response to a January 29, 1980, request by DHEC for technical assistance. The NRC office of Nuclear Material Safety and Safeguards (NMSS) produced NUREG-0879, "Environmental Assessment for the Barnwell Low-Level Waste Disposal Facility" (NRC, 1982). Although South Carolina is an Agreement State and therefore has licensing authority for low-level waste disposal in South Carolina, the State's actions in this regard are not within the purview of the National Environmental Policy Act (NEPA) of 1969. Consequently, a formal environmental impact statement has never been prepared on the Barnwell site. The NMSS assessment satisfied the DHEC request for an environmental assessment, and also served as a response to two other inquiries: (1) a General Accounting Office (GAO) report to Congress questioning the ability of existing commercial sites to retain radioactive wastes and (2) a House Government Operations Committee recommendation aimed at improving the performance of LLRW sites.

NRC staff recommended continued operations with due consideration given to the staff's recommendations. The staff believed that implementation of their recommendations would improve the short- and long-term overall effectiveness of the Barnwell site. These recommendations were considered and incorporated into on-going site operation and environmental monitoring practices at the Barnwell site, as appropriate.

5.1.2 Disposal Site Characterization History Summary

In 1969, the first detailed site evaluations were performed as part of the original licensing phase for the Barnwell site. The geologic and hydrological findings are described in Law, 1971. No additional detailed evaluations were conducted until after tritium was detected outside disposal trenches in the late seventies. As a result of this finding, CNS increased its level of environmental characterization and monitoring, and initiated additional site studies. In 1982, the USGS published a comprehensive study of the site geology and hydrology, including an assessment of the extent of tritium (Cahill, 1982). The site stratigraphy and lithologic interpretation (from the Cahill study) is provided in Figure 5-1. Other stratigraphic interpretations and nomenclature are discussed in Nystrom, *et al.*, 1991.

Since 1985, CNS has implemented several projects to further characterize site geology. CNS designed these studies to provide baseline characterization data for ground water modeling. Beginning in 1987, CNS expanded its focus to include evaluations of contaminant transport from the disposal site. These efforts by CNS in close coordination with DHEC continue to present.

Additional USGS studies published in 1987 characterized disposal site water balance (Dennehy, et al, 1987). USGS results provide justification for recharge values used in CNS groundwater transport models.

FIGURE 5-1

Stratigraphic and Lithologic Interpretation of The Barnwell site

(Adapted from Cahill, 1982)

Stratigraphic Unit	Depth (feet)	Lithology
Hawthorn and Barnwell Formations	0	Red, yellow, and purple sandy clays with white and dark brown sands
McBean formation	100 200	Medium to coarse brown, white, and yellow sands
Congaree Formation	300	Coarse white and brown sands with some quartz gravel
Ellenton Formation — Clay Unit	400	Dark gray to black micaceous clay and sandy clay
Ellenton Formation — Sand Unit		Medium to coarse white and gray sand with streaks of brown clay and quartz gravel
Middendorf Formation	500	Brown and white, coarse sand and gravel with streaks of brown and white clay
	1100	Hard brown clay

5.2 Groundwater Conditions

Annual precipitation at the burial facility is approximately 47 inches. Approximately 14 to 17 inches of precipitation per year are believed to recharge the groundwater on the Barnwell site (Dennehy, et al, 1987). The available moisture and the hydraulic conductivity of the near-surface sediments control groundwater recharge. Once moisture leaves the near surface, it is free to drain to the water table. To minimize groundwater recharge over the disposal trench area, CNS has installed engineered trench caps.

Hydrological studies conducted by Cahill (1982) and CNS environmental monitoring data have shown that the shallow groundwater flow system near the burial facility can be separated into two zones. These two zones are traversed by groundwater, which originates at the burial site. Beneath the disposal site, Zone 1 extends from the water table (approximately 30 feet beneath the land surface) to approximately 70 feet beneath the land surface. Zone 1 is considered to be restricted to the high- fines (>10% fines) sediments of the Hawthorn and Barnwell Formations. Zone 2 is considered to occur in the low fines (<10% fines) sediments of the Barnwell Formation. The hydraulic conductivity of Zone 1 is less than the hydraulic conductivity of Zone 2. Groundwater that recharges on the site flows steeply through Zone 1 and then almost horizontally through Zone 2.

Typically, the water table rises and falls seasonally reflecting the time variation of groundwater recharge. The results of the study conducted by Dennehy, et al (1987) have shown that precipitation exceeds evapotranspiration during the fall, winter and spring. This observation is reflected by the water table's maximum elevation occurring during the months of May to June.

The potential movement of radioactivity from the disposal trenches to an off-site location takes place over a long time. Therefore, CNS has used average water elevation data to predict the movement of radioactivity.

5.3 Water Table Conditions

CNS monitors the elevation of the top of the water table beneath the Barnwell site by means of a set of monitoring wells screened in ground water Zone 1. One of the primary reasons for monitoring water table elevation is Condition 97g of License 097, which requires that the bottom of a disposal trench be designed to be at least five feet above historical high water table elevations in the immediate area.

Although CNS constructs disposal trenches at least five feet above the horizontal high water table, there have been high water tables that have exceeded previous historical highs. These high water tables, which last a few months, were above the bottom of the trenches in selected areas. However, high water tables do not appear to significantly affect the movement of radioactivity in groundwater.

5.4 Environmental Conditions

In CNS' groundwater sampling program, no above-background levels of radionuclides, other than tritium and carbon-14, have been detected in downstream groundwater monitoring wells. Tritium is the only radionuclide detected in significant concentrations in the site's groundwater monitoring wells. Tritium has been observed in monitoring wells downgradient of the trench disposal area.

To address these tritium findings, CNS has added enhanced trench covers designed to essentially eliminate infiltration. The elimination of infiltration should eliminate further tritium contribution to the groundwater from existing trenches. Trench cap designs and locations are described in Section 6.2.1.

Carbon-14 has also been measured outside disposal trenches. The concentrations in Zone 2 monitoring wells are generally low; however, the distribution appears to be similar to tritium.

CNS has installed enhanced caps over selected areas of the site. Current environmental monitoring data from selected monitoring wells located immediately downgradient of the southern trench area (phase 1 cap) generally show a reduction of tritium concentrations. Groundwater monitoring will continue downgradient of all newly-capped areas, and the results of the monitoring program will be reported to DHEC in routine environmental monitoring reports.

CNS has recently estimated maximum radiological dose rates to any member of the public by direct measurements and models and summarizes these evaluations in the Environmental Radiological Performance Verification (ERPV) report (CNS, 2000b). The ERPV projects current environmental measurements to estimate peak dose rates at a compliance point located at the CNS property boundary. In its performance modeling of the site, CNS has evaluated the groundwater, surface water and air pathways, the primary means by which radioactivity could reach any member of the public after the disposal site closes. For the water pathway, CNS has assumed no engineered cover, and movement of radioactivity under natural (average) groundwater and surface conditions. Groundwater conditions were determined from water elevation measurements taken over 12 years from over 200 monitoring wells, which are part of the Barnwell site monitoring program. Similarly, radiological conditions are based on measurements made from 1982 to 2000 from over 200 monitoring locations.

The current tritium area at the Barnwell site extends from the disposal area to Mary's Branch. CNS has estimated a hypothetical peak dose where Mary's Branch first leaves CNS property. Results show the peak dose rate is less than 25 millirems per year for a continuous consumer of surface water where the stream leaves CNS property (CNS, 2000b). There are no current users of groundwater in this area; therefore, real dose rates to any member of the public are zero.

To address contingency at the compliance point, CNS has provided SCDHEC with an estimate to perform groundwater treatment near the headwaters of Mary's Branch. The financial analysis for this scenario is provided in Section 8.5.

CNS' air pathway analysis assumed potential emission of gases containing radioactivity due to decomposition of waste. To address gases, attempts were made during the Fall of 1998 and 1999 to measure radionuclides in air in the breathing zone when soil gas concentration is expected to be maximum. Other than naturally-occurring radon gas, no gaseous radioactivity was detected on the disposal area. Therefore, no dose to any member of the public adjacent to the disposal site is expected from radioactive gas.

As part of the site closure and post-closure observation, CNS will provide DHEC with updated environmental reports and site performance evaluations, which will show the status of the environment on and beneath the surface of the site. The latest ground water monitoring data will be incorporated into these future evaluations.

6.0 INTERIM SITE STABILIZATION AND CLOSURE PLAN

The Interim Site Stabilization and Closure Plan (Closure Plan) embodied in Section 6 provides a framework and plan for activities aimed at achieving site stabilization. In this plan, CNS has identified the tasks required to complete closure of the disposal facility, provided cost and schedule projections, and summarized closure activities completed to date. The closure activities detailed in this plan have been selected and designed to meet and exceed closure performance objectives. The components of the plan are summarized below and detailed in this and subsequent sections.

Section 6.0 is divided into several subsections. The five primary subsections are facility decontamination and decommissioning, site stabilization, environmental monitoring, performance assessment and closure cost and schedule. The descriptions in Section 6 are focused on the activities anticipated to occur up to and during the two-year Phase I closure period FY 2008/2009 and 2009/2010. A separate section describes the second closure period (Phase II) following in-region operations. Phase II closure will involve minimal work because of the limited area affected during in-region operations. Decommissioning work planned during Phase I closure is summarized below.

Facility decontamination and decommissioning involves the radiological survey, decontamination (as required) and disposition of structures and adjacent areas on State property. Some structures will be dismantled and disposed on-site. CNS proposes to leave certain structures for in-region operations and ultimately custodial use. CNS will also perform a closed-site survey to demonstrate that surface areas of the closed disposal site are free of contamination and that radiation above trenches is essentially background.

Site stabilization activities such as enhanced capping, final grading, and surface water management are the primary elements required to ensure long-term site stability and performance. In this plan, CNS has designed the final closure facility to minimize erosion, control runoff, and limit infiltration into disposal trenches, all in an effort to ensure performance objectives are achieved and can be maintained through in-region-operations, institutional control and beyond.

Closure period environmental monitoring is specified in Section 6.5 of this plan. During Phase I closure and post-closure, CNS plans to update and finalize site performance assessment for closed site areas. This activity will incorporate all appropriate disposal, site characterization and environmental monitoring data into a final evaluation and projection of facility performance. Certain related activities may be performed before the closure period as discussed in Section 6.9.

In this plan, CNS has identified required closure activities, associated costs and schedules. Three-fourths of the existing disposal area has been fitted with enhanced caps and is already in its final closure configuration. Other closure activities are planned to occur in conjunction with on-going waste disposal operations during the next eight years. These activities are financed from the decommissioning fund. This approach allows CNS to optimize the use of existing personnel and other resources at the site and minimize decommissioning costs.

For the purposes of this plan, the actual Phase I closure period is assumed to begin after eight years which is the start of in-region-only operations. CNS assumes remaining closure activities can be completed within two years concurrently with in-region-only operations (as defined in S1129). During the closure period, all closure tasks, associated support functions and site maintenance and monitoring functions are paid for from the decommissioning fund. Immediately following completion of closure period activities, CNS will transition to post-closure observation. Post-closure and long-term care activities for closed areas of the site are discussed in Section 8, and will be paid from remaining monies in the decommissioning fund and the extended care maintenance fund. CNS assumes in-region-only operations will last 30 years, followed by the Phase II closure and post-closure observation period for the in-region operations area. 100-year institutional control will begin following Phase II post-closure.

Phase I closure activities, costs and schedules are provided in Sections 6.1 through 6.10. Closure financial assurance is discussed in Section 6.11. Phase II closure is discussed in Section 6.12.

6.1 Facility Decontamination and Decommissioning

6.1.1 Building and Equipment Decontamination and Decommissioning

The buildings at the CNS Barnwell site are described in Section 3.3.
Only the structures that are within or adjacent to the disposal site restricted area fence are considered in this plan. These structures will be surveyed and decontaminated as necessary for their intended use. The structures may be left for use during in-region operations and subsequently by the site custodian during the long-term care period, retained for continued

CNS service activities not directly associated with the disposal site or dismantled and buried on site. Equipment not needed for subsequent activities will be removed from the site.

The results of routine surveys for direct radiation and contamination levels in each building and their associated components were reviewed to summarize the radiological status of these structures. Based on current radiological conditions, the appropriate structures will be dismantled in accordance with the precautions and methods described below.

The disposition of structures on State property is summarized in Table 6-1. The buildings dispositioned as "CNSIR" will remain to support disposal site operations, maintenance and monitoring during the in-region operations period. Those identified as "dismantle" will be decommissioned during the Phase I closure period and buried on site. Buildings identified as "CNSNS" will be used to support other CNS or parent company operations. A summary of the radiological status for site structures is given in Table 6-2. A summary of the radiological status of components that are used in these buildings is provided in Table 6-3.

Research into the history of contamination events in or around site structures consisted of interviewing long time site employees and reviewing incident reports. CNS identified several historical spill events through this process. CNS found, for the most part, that CNS had remediated these spills at or near the time of occurrence. CNS expects, based on its interviews and recent characterization efforts, some soil contamination in the area around the Site Operations Maintenance Building, due to early site operations. This area is identified for further characterization and remediation.

Table 6-1 Site Structures			
Number[1]	Name	Status	Disposition[2]
2	Receiving Warehouse No. 2	Clean	CNSIR/CNSNS
3	Warehouse No. 3	Clean	CNSNS
7	Liner Operations Building	Clean	CNSNS
8	Site Building	Clean	CNSIR
10	HP Building	Clean	CNSIR
11	Site Operations Maintenance Building	Soil Contamination	Dismantle
13	Cask Preservation Building	Contamination	Dismantle
14	Cask Maintenance Building	Clean	CNSIR
15	Field Services Maintenance Warehouse	Contamination	Dismantle
16	Grounds Maintenance Shop	Clean	CNSIR
19	Drilling Equipment Storage Trailer	Clean	CNSIR
20	Instrument Calibration Shop	Clean	CNSIR/CNSNS

[1] The numbers are keyed to CNS Drawing B-500-D-300 for easy reference.
[2] Disposition: (a) "CNSNS" - continue using building for other parent company operations; (b) "CNSIR" - use facility during in-region operations.

Table 6-2 Site Structures – Radiological Status as of May, 1999*			
Number	Name	Removable Contamination	
		Maximum dpm/100cm^2 Beta/gamma	Mean mrem/hr
2	Receiving Warehouse No.2	<200	0.08
3	Warehouse No.3	<200	0.06
7	Liner Operations Building	<200	0.08
8	Site Building	<200	0.06
10	HP Building	<200	0.06
11	Site Operations Maintenance Building	<200	0.06
13	Cask Preservation Building – Washdown	<200	0.06
13	Cask Preservation Building – Sandblast	4395	2.0
14	Cask Maintenance Building	<200	0.2
15	Field Services Maintenance Building	5000	5.0
16	Grounds Maintenance Shop	< 200	0.06
19	Drilling Equipment Storage Trailer	< 200	0.06
20	Instrument Calibration Shop	<200	0.08

* Survey data based on 6 months' data retrieved from routine surveillance surveys conducted in accordance with CNS procedures.

Table 6-3

Site Structures – Components Radiological Status

Name (Number)	Components	Ducts	Pipes	Drains	Tanks
Receiving Warehouse No.2 (2)	<200 dpm/100cm^2	None	Potable water supply	None	None
Warehouse No.3 (3)	<200 dpm/100cm^2	Ventilation system - <200 dpm/100cm^2	None	None	None
Site Building (8)	<200 dpm/100cm^2	Ventilation system - <200 dpm/100cm^2	Potable water supply	Sanitary sewer drains & decon sink drain - <200 dpm/100cm^2	sanitary sewer septic tank and decon sink holding tank - <200 dpm/100cm^2
Cask Maintenance Building (14)	<1000 dpm/100cm^2	None	Air Supply/ Floor Drain	Floor Drain (1) - <200 dpm/100cm^2	1 Buried HIC - <200 dpm/100cm^2
Grounds Maintenance Shop (16)	<200 dpm/100cm^2	None	None	None	None
Drilling Equipment Storage Trailer (19)	<200 dpm/100cm^2	Ventilation System* <200 dpm/100cm^2	None	None	None

* New ventilation system - CNS has not surveyed the duct system; however, routine radiological surveys of the trailer have shown <200 dpm/100cm^2.

Table 6-1 identifies three buildings to be dismantled and disposed on site. The general radiological conditions and proposed decommissioning methods for each building and area are discussed below. The buildings will be dismantled, as necessary, for movement to the trench for disposal.

The Cask Preservation Building is expected to have contamination on portions of the walls and floor. The metal walls will be decontaminated to acceptable levels, less than 220 dpm/100cm^2 removable alpha and 2200 dpm/100cm^2 beta/gamma. The contamination on the concrete floor will be chipped up and removed. The HEPA filters and ventilation system will be removed and bagged for disposal, as appropriate. The water and sludge from the washdown facility will be solidified and disposed. This is the only building expected to produce radioactive waste. The components described above with contamination above acceptable levels will be packaged and disposed in vaults. Other building demolition, rubble, and soils will be placed directly into a trench.

The Field Services Maintenance Building and the Site Operations Maintenance Building have been associated with radiological work and will be considered suspect for contamination, although none is expected. The buildings will be surveyed to the release limits above and then dismantled as clean rubble for disposal. Any contaminated areas found above the limits will be decontaminated to free release limits and resurveyed.

Since contaminated equipment has been historically serviced and stored around the Site Operations Maintenance Building, Field Services Maintenance Warehouse and Cask Preservation Building, CNS plans a radiation survey in this area. Radiation surveys will occur after stored equipment has been moved and the buildings are dismantled. Radiation surveys will include collecting surface soil samples on 10m grid and four shallow borings to the water table.

For planning purposes, CNS assumes that soils will be removed from a trapezoidal area of 74,000 square feet to a depth of five feet, resulting in a total soil volume of 370,000 cubic feet. The trapezoidal area will extend 239 feet along the current site boundary fence behind the on-site ancillary facility area and encompass the Cask Preservation Building, Field Services Maintenance Warehouse, and Site Operations Maintenance Building.

The estimated volume of site-generated waste that will be produced during facility and equipment decommissioning is approximately 60,800 cubic feet of building rubble and 370,000 cubic feet of soil. Based on the levels of contamination and nature of decommissioning waste (rubble, soil), these materials will be buried in remaining portions of active trenches and/or in a small decommissioning trench, which will be located in an area approved for LLRW disposal on the disposal site. Decommissioning waste disposal locations will be determined at closure. The decommissioning rubble and soil will be transported to the trench in dump trucks.

The construction costs for the decommissioning waste trench have been estimated in Table 6-4.

Table 6-4 D & D Trench Construction	
CNS Labor	$11,880
Contractor Construction	$122,815
Fee	$39,062
Total	$173,757

6.1.1.1 Contamination Control Provisions

Characterization surveys of the structures will be performed before dismantlement begins. Based on recent surveys, the buildings being dismantled do not have high levels of removable contamination, and the levels on the building components are less than allowed on waste packages by DOT regulations.

To minimize the potential for spreading contamination during transport and offloading, the building rubble may be misted with water to prevent the generation of dust or transported in covered dump trucks.

The Cask Maintenance Building will be surveyed and decontaminated. The metal walls will be decontaminated to acceptable levels. Any contamination exceeding the applicable limits on the concrete floor will be chipped up and removed.

Routine surveillance surveys indicate that the Cask Preservation Building has the potential to cause significant radiation exposure due to the levels of removable contamination found on most interior surfaces. This building has been used for abrasive decontamination of various site equipment, and removable contamination is found on most surfaces. The controls that will be used to prevent personnel contamination and airborne radioactive material include vacuuming surfaces and/or fixing the contamination in place prior to dismantlement. Personnel entry and activities will be monitored, and controls may include respiratory protection devices in addition to protective clothing. These activities shall be conducted in accordance with established CNS radiation protection procedures.

6.1.1.2 Site Equipment

There are approximately 58 pieces of heavy and light equipment on site. The equipment will be evaluated for existing value and potential for continued service. Radiological surveys will be performed to ensure that equipment is not contaminated. Decontamination techniques, such as abrasive grinding, wire brushing, wiping, decontamination washing, cutting-out of material, and sandpapering, may be used to remove contamination from accessible areas. Areas that are inaccessible will be evaluated by process knowledge to determine the potential for radiological contamination. If the potential exists and verification cannot be done, the equipment will be considered contaminated. Serviceable equipment will be removed for subsequent use. Non-salvageable equipment will be surveyed and released from site for unrestricted use.

6.1.1.3 Safety Controls During the Building Dismantlement

Chem-Nuclear has thoroughly reviewed the potential health and safety hazards associated with dismantlement of site buildings and has identified appropriate control measures that will prevent personnel injuries. Regular surveillance of dismantlement activities will be performed by a CNS Safety Representative to ensure worker compliance with safe work practices and applicable company and Occupational Safety and Health Administration (OSHA) safety requirements. CNS will ensure that workers are appropriately trained to perform assigned tasks in a safe manner and that only certified heavy equipment operators are used.

Table 6-5 summarizes a task-by-task hazard analysis, that identifies major tasks during the building dismantlement phase and the associated hazards and measures to control those hazards.

Table 6-5

Hazards Analysis For Building Dismantlement

TASK OR STEP	POTENTIAL HAZARDS IDENTIFIED	RECOMMENDED CONTROL MEASURES
Disconnect power (at main transformer), telephone and water.	Electric shock; fall; pinch points	Have SCE&G disconnect power at transformer; Bell South disconnect telephone lines. Personnel will wear electrical insulating gloves and other appropriate PPE; inspect tools prior to use; train personnel in the safe use of tools.
Verify utilities are disconnected	Electric shock; fire; explosion	Have electrician verify electricity is disconnected in each building; verify water and phone lines are disconnected.
Identify underground utility pipes/lines.	None	Have utilities identify/mark underground utilities and disconnect if necessary.
Remove propane tanks.	Explosion; fire; crushing	Have local gas company disconnect and remove propane tanks. Monitor for explosive atmosphere; use non-sparking tools; purge gas lines, have personnel maintain a safe distance from work area.
Erect scaffolding	Fall; pinch points; crushing; falling objects	Ensure personnel are qualified to erect scaffolding and operate forklifts, are trained in the safe use of tools, use appropriate PPE and fall protection devices and do not stand beneath scaffolding or overhead work activities; inspect scaffolding prior to use; keep overhead platforms free of debris; lower small or heavy objects down in baskets.
Dismantle wooden interior structures and stack on truck.	Fall; crushing; punctures; pinch points; cuts; falling objects	Ensure personnel are trained in the safe use of tools, use appropriate PPE and fall protection devices and do not stand beneath overhead work activities; keep overhead platforms free of debris, remove or flatten protruding nails; sound truck horn to alert workers of moving vehicle; chock vehicle wheels.
Remove metal siding and roof from buildings. (Unscrew roof/siding and lower to truck for stacking using crane or forklift.)	Fall; crushing; pinch points; cuts; repetitive motion trauma; electric shock; falling objects	Use power tools vs manual screwdriver; use Ground Fault Circuit Indicator (GFCI) when applicable; ensure personnel are trained in the safe use of tools, use appropriate PPE and fall protection devices and do not stand beneath overhead work activities or crane loads; keep overhead platforms free of debris; sound truck horn to alert workers of moving vehicle; chock vehicle wheels; use only trained crane operators/riggers.
Dismantle building frame and lower to trailer.	Fall; crushing; pinch points; cuts; repetitive motion trauma; falling objects	Use power tools vs manual wrenches whenever practical; ensure personnel are trained in the safe use of tools, use appropriate PPE and fall protection devices and do not stand beneath overhead work activities or crane loads; keep overhead platforms free of debris; sound truck horn to alert workers of moving vehicle; chock vehicle wheels; use only qualified crane operators/riggers and forklift operators.
Various activities	Noise	Monitor sound level and use appropriately selected hearing protection
Remove fixed radioactive	Airborne radioactivity, dust	Ensure personnel are trained in the safe use of tools, use appropriate PPE (including respiratory protection); use anti-

Table 6-5 Hazards Analysis For Building Dismantlement		
TASK OR STEP	POTENTIAL HAZARDS IDENTIFIED	RECOMMENDED CONTROL MEASURES
contamination from concrete.	nuisance and silica, repetitive motion trauma	vibration material on vibrating tool handles whenever practical.
Breakup and remove non-contaminated concrete pad and load on truck.	Airborne dust (nuisance and silica); repetitive motion trauma; crushing; pinch point	Ensure personnel are trained in safe use of tools, use appropriate PPE (including respiratory protection); use heavy equipment vs vibrating tools whenever practical; use certified heavy equipment operators; sound truck horn to alert workers of moving vehicle; chock vehicle wheels.
Grade area to desired topography.	Heavy equipment; crushing	Use certified heavy equipment operators; have personnel maintain a safe distance from earth moving activities; have operators use seatbelts and appropriate PPE.

6.1.2 Soil Survey and Characterization

The subsurface areas around all on-site buildings and lined holding ponds must be characterized to evaluate levels of radiological contamination. The following surface and subsurface site characterization is planned:

* Surface gamma surveys on a 10-meter by 10-meter grid pattern, including the area of the Site Operations Maintenance Building.

* Surface soil samples on a 10-meter by 10-meter grid pattern at six-inch depth intervals analyzed for gamma radioactivity and tritium. Four samples will be collected per grid, equally spaced between the corner and the center, or at areas of elevated gamma activity. Sampling will stop when two consecutive grid locations are at or below the acceptable activity level. For example, at the lined holding pond area, initial grid (10m X 10m) will be established at the outer boundary that encompasses the existing perimeter. If this grid meets the release criteria, an additional grid (10m X 10m) will be established on the outside edge and sampled. If the second grid meets the release criteria, no additional grids will be required. If the first grid does not meet the release criteria, an additional grid will be established on the outside edge. It will be sampled and if it

meets the release criteria, an additional grid on the outside will be established that must also pass the release criteria prior to release.

* Deep soil sampling in areas around the Site Operations Maintenance Building, Cask Preservation Building, and areas of known leaks or spills may occur to depths of as much as 30 feet. Samples will be analyzed for gamma radioactivity and tritium. Sampling will stop when two consecutive samples are at or below the acceptable activity level.

* Contaminated soil will be removed as part of closure and decommissioning. The amount of materials removed will depend upon the level of contamination. Removal of contaminated soil may involve excavations over five feet deep. These excavations will be designed in accordance with OSHA Subpart P §1926.650.

* All heavy equipment operations associated with this activity will be performed in accordance with CNS safety procedures.

6.1.3 Site Structures, Equipment and Soil Decommissioning Cost Summary

Table 6-6 lists the estimated costs of facility and equipment decommissioning activities. The number of samples is based on the grid and sampling methodology described in Section 6.1.2 and additional samples collected for quality assurance. These costs assume no disposal taxes or surcharges applied to site-generated decommissioning waste. Site-generated wastes have not historically been assessed these charges.

Table 6-6 Structures and Equipment Decommissioning Costs		
General HP Support	CNS Labor CNS Equipment	$124,800 $22,500
Preliminary Building Surveys	CNS Labor	$20,800
Building Dismantlement/Disposal	CNS Labor Leased Equipment	$60,480 $105,000
Soil Excavation	CNS Labor Contractor Leased Equipment	$53,360 $2,622 $108,560
Equipment Release		$6,600
Radiological Analysis (500 samples)		$118,150
Fee		$180,633
Total		$803,505

6.1.4 Closed-Site Survey

In order to ensure that the site surface is free of contamination and that direct gamma radiation is essentially background, an extensive soil sampling and survey program will be undertaken. After completion of Phase I closure activities, the entire restricted area will be sampled and surveyed.

The site will be divided into grid blocks approximately 100 feet on a side. At the center of each grid block, one gamma radiation level measurement will be made at one meter from the surface using a pressurized ionization chamber. One composite soil sample will be collected for each grid. The composite will be prepared from five samples taken within the grid from zero to six inches. These samples will be taken at the grid center and four points equidistant from the grid corner and center. The composite soil samples will be analyzed for radionuclides and RCRA constituents. The data collected during the closure survey will be evaluated in accordance with the appropriate regulatory criteria.

Table 6-7 lists the costs of final site surveys. A report of all data and evaluations will be prepared and submitted to DHEC for their review and file.

Table 6-7 Final Site Survey Costs		
Land Surveying	Contractor	$33,600
Direct Gamma Measurements, Soil Sampling	CNS Labor	$35,200
	CNS Equipment	$3,000
Soil Analysis (tritium, RCRA, gamma)		$107,500
Fee		$51,997
Total		$231,297

6.1.5 Physical Security

Security personnel will maintain a 24-hour a day schedule. Their duties include controlling entry and exit at site access locations, making daily security checks for intruders, and checking for lock tampering or evidence of forced entry at gate locations.

A seven-foot high fence secures the licensed disposal area. The fence is galvanized steel mesh with three strands of barbed wire running parallel to the mesh and extending outward from the top for 18 inches at a 45° angle. Galvanized steel posts are inside the fence fabric and set in circular concrete anchor footings for stability. Horizontal rails along the top support the fence fabric and add bracing. The fence is checked for sagging, leaning, torn fabric, erosion or gaps underneath, fallen or leaning trees and loose or broken barbed wire. All discrepancies are noted and repairs are implemented as soon as possible.

Table 6-8 Site Security (Annual)	
CNS Labor	$147,681
CNS Equipment	$12,070
Fee	$46,328
Total	$206,079

During Phase I closure, CNS may recommend adjusting the site property boundary to provide area adequate to maintain site stability. Fence will be re-located as necessary to encompass site property boundary. Proposed licensed disposal area property boundary is discussed further in Section 6.7.

6.2 Site Stabilization

This section describes those closure activities directed at achieving final closure and stabilization of the disposal site. Disposal site stabilization is accomplished by installing enhanced caps on disposal trenches and designing efficient surface water management controls. CNS' goal is to establish site conditions that eliminate, to the extent practicable, the need for on-going active maintenance during institutional control so that only surveillance, monitoring, or minor custodial care are required.

6.2.1 Disposal Trench Closure

After waste burial in a disposal trench is complete and backfill installed, CNS completes trench closure by installing an enhanced trench cap. CNS first started installing enhanced caps on certain older trenches in 1991. Enhanced cap construction became a routine part of disposal trench construction procedures in 1995. CNS plans to continue capping existing trenches and, at closure, will cap most remaining trenches. Trenches to be used for in-region operations will be capped at a later date. Design, construction costs, and schedule for capping are discussed in subsequent sections.

6.2.1.1 Capping Rationale

Prior to 1995, areas to be capped were selected based on the performance history of those areas and CNS' knowledge of waste form and type. In 1995, responding to the 1995 amendments to DHEC regulation 61-63, Title A, Part 7, "Licensing Requirements for Land Disposal of Radioactive Waste," CNS proposed incorporating enhanced caps on all disposal trenches to minimize infiltration. At the same time, CNS recommended placing all waste in concrete disposal vaults to enhance long-term trench stability. These changes were intended to improve the disposal facility's overall ability to meet performance objectives and have since been included by DHEC as requirements of License 097.

6.2.1.2 Enhanced Cap Design

The CNS enhanced cap consists of multiple layers of earthen and geosynthetic materials, specifically selected to minimize infiltration. Cap layers are (from bottom to top) compacted clayey sand; bentonite mat; high-density polyethylene (HDPE) geomembrane; sand drain layer; and general soil cover. The function of each component is described below.

The HDPE, bentonite mat, and clayey sand comprise the vertical barrier to water infiltration. The overlying sand drain directs water percolating through the soil cover laterally to the perimeter of the cap where it drains as surface runoff away from the capped trench area. The soil cover protects the drain and barrier layers from erosion and other physical/chemical effects and supports vegetation growth. Vegetation protects the cap surface from erosion and contributes to water removal through transpiration. All cover components and the concrete disposal vaults below work together to ensure the long-term integrity and performance of the disposal trench cover.

The surface configuration and geometry of each cap area are unique, controlled by such factors as trench top elevations, sizes of trenches, and runoff drainage requirements.

6.2.1.3 Cap Enhancement Projects (1991 to 2000)

As of 2000, CNS had completed approximately 80 acres of enhanced cap, covering 65 trenches (locations shown on CNS Drawing #B-500-D-300). All construction phases to date have involved older closed trenches (previously covered with compacted clay and soil materials). Data for each capping phase including date of completion, covered area, construction cost, and number of trenches involved are included in Table 6-9 and summarized below.

TABLE 6-9
HISTORICAL ENHANCED CAPPING SUMMARY

Phase	Date of Completion	Acres	# of Trenches Covered	Approximate Cost ($ in Millions)
1	1/92	12.5	20	1.7
2	2/94	9	10	1.4
3	7/95	26	12	4.1
4	5/97	22	14	3.0
5	9/98	10	9	1.65
Total		79.5	65	11.85

CNS completed the first enhanced cap during 1992 on the earliest site trenches located in what was termed the “Old Southern Trench Area.” This cap (Phase 1) involved 20 trenches and approximately 12.5 acres. Phase 1 cap design was identical to all subsequent caps, except HDPE geomembrane thickness (40 mil) and height of protective toe drain stone were less. CNS has since changed the height of protective toe drain stone on the Phase 1 cap to current standards, improving erosion protection.

Phase 2 cap, completed during 1994, covered 10 trenches and approximately nine acres. For Phase 2, HDPE geomembrane thickness was increased from 40 mils to 60 mils, simplifying geomembrane installation because the greater thickness is easier to seam and wrinkles less. This area, like Phase 1, includes mostly early (pre-1980) trenches, completed before many of the waste form improvements of the 1980’s.

Phase 3 cap, completed during 1995, covered 12 trenches and approximately 26 acres. The Phase 3 cap area consists of 1000-foot long trenches, which were completed in the late 1970's and early 1980's. The cap design is similar to that used for Phase 2, except the large cap size led to the inclusion of surface drainage swales within the cap perimeter. These swales collect and direct surface runoff and internal sand drain percolate to the edge of the capped area.

Phase 4 cap, completed during 1997, covered 14 trenches and approximately 22 acres. The Phase 4 cap area consisted of larger more recent Class A trenches and a few slit trenches, all completed during the 1980's. The cap design is very similar to that used for Phase 3, including the use of internal surface drainage swales. The southwest edge of Phase 4 was left incomplete as a tie-in for the Phase 5 cap, planned immediately to the south.

Phase 5 cap, completed during 1998, tied directly to Phase 4 cap to the north, thereby providing continuous cap coverage between contiguous construction phases. Phase 5 covered nine trenches and approximately 10 acres. Phase 5's internal swales originated in and were an extension of swales built during an earlier cap phase (Phase 4).

CNS is evaluating actual enhanced cap performance by studying trends observed in monitoring wells and trench standpipes.

6.2.1.4 Future Enhanced Cap Construction

CNS will install enhanced cap on all remaining non-capped trenches and all future trenches. Cap designs are anticipated to remain essentially the same as described in Section 6.2.1.2. Closure capping costs (in Table 6-10) are estimated based on the actual cost of recent cap projects. Cap construction estimates include the cost of planning, design, construction materials, and installation of cover vegetation. CNS plans to cap 32 acres during the next eight years, after which approximately eight acres will remain to be capped. For the purposes of this plan, CNS assumes the closure activities period comprises the last two years of the ten-year plan period during which remaining trench areas will be capped. A fee for services is incorporated in the price of each capping phase.

Table 6-10
Ten-Year Plan Enhanced Capping Schedule

Cap Phase	Construction Start Date	Area (Acres)	Estimated Cost
6	2001	19.0	$4,289,250
7	2003	5.3	$1,196,475
8	2005	2.0	$451,500
9	2007	5.8	$1,309,350
10	2009	5.9	$1,331,925
11 (remaining trenches)	2009	2.4	$541,800
Total		40.4	$9,120,300

6.2.2 Surface Water Management

Surface water management is comprised of three primary elements: final site topography, drainage pathways and ponds. These elements are combined in the closure surface water management and final topography drawing (Figure 6-1), which includes site topographic and surface drainage features.

Since 1991, CNS has made significant progress towards achieving final grades on the site by constructing 80 acres of enhanced cap. Each enhanced cap has been designed and graded to closure grades and planted in grass. Most non-trench areas are currently at or near final grade except parts of the site currently designated for closure water management. CNS believes that contouring the site to final grades, constructing properly sized water management ponds, and establishing a healthy grass cover will minimize long-term site maintenance requirements and assure site stability. The following sections describe the potential surface water management system and final topography.

6.2.2.1 Surface Water Management Ponds

CNS proposes to reconfigure site water management ponds and surface water conveyances to handle runoff expected from the closed disposal site. The new ponds will be sized to ensure no ponding occurs on or near disposal trenches.

The primary pond design criteria are (1) adequate separation of pond areas from disposal trenches and (2) sizing the ponds for high on-site capacity and controlled off-site flows.

To evaluate potential runoff volumes, the disposal site will be divided into drainage areas. Most of the site (~185 acres) drains west to the existing water management ponds on the west side of the site. The southeast portion of the site (~64 acres) currently drains to a detention pond on the southeast corner of the site.

The potential new west water management pond would be constructed by removing the berm between the existing north and south ponds and the low area immediately east of the ponds. Fill would be placed on the east side of this low area to separate pond areas from disposal trenches. An overflow would be located on the southwest corner of the new combined pond to direct water to additional water management features off-site. The overflow elevation is planned for approximately 242 feet AMSL, ensuring water does not back-up on surrounding trenches while also providing significant on-site storage. The potential capacity of the combined north and south pond would exceed the volume of runoff produced by a 100-year 24-hour storm. This approach ensures no routine surface water discharge from the west side of the site.

The potential southeast water management pond would be constructed by enlarging the current sediment detention pond located at the southeast corner of the site. Final location and size will be determined through detailed design and analysis. Constructing this basin will primarily involve excavation. Like the west pond, it will be designed to contain the 100-year, 24-hour storm. The pond will consist of a permanent pool that will evaporate and percolate, a portion that will slowly drain through appropriate flow structures off-site, and will be designed to include emergency spillway provisions. The water that drains from the pond will discharge onto adjacent CNS property east of the site and infiltrate into sandy, well-draining native soils.

The conceptual designs described above were developed by analyzing surface water drainage conditions anticipated for the closed disposal facility, then using Soil Conservation Service (SCS) methods to estimate runoff volumes. Detailed analysis and computations will be required to finalize pond sizes and configurations. These analyses may result in different plans and concepts for site water management. CNS plans to proceed during 2000 with detailed design of the west management pond. Final design of the southeast pond will occur after final trench configurations are established in the southeast drainage area.

The estimated earthmoving volumes associated with current proposed closure water management ponds are provided in Table 6-12. Earthmoving and pond design costs are provided in Table 6-11.

Table 6-11
Pond Reconfiguration Costs

West Pond		
Land Survey	Contractor	$ 11,040
Design / Construction	Contractor	$397,900
	CNS Labor	$32,200
Fee		$127,931
	Subtotal	$569,071
Southeast Pond		
Land Survey	Contractor	$31,680
Design / Construction	Contractor	$382,800
	CNS Labor	$23,980
Fee		$127,153
	Subtotal	$565,613
Total		$1,134,684

6.2.2.2 Final Topography

CNS has developed the final Barnwell site topography (Figure 6-1) to achieve: (1) surface contours to promote passive surface water management, (2) optimized sloping over trench areas to drain water efficiently away, while minimizing erosion; (3) efficient, cost-effective configurations that use materials wisely and fit with surrounding topography, and; (4) elevations that provide minimum five feet of earth over waste. The majority of the site (counting completed enhanced caps) is considered to be at final grade. For trench areas without enhanced cap and some other site areas, substantial amounts of earthmoving remain. These areas are discussed below.

For trench areas without enhanced cap, final grades will be determined and submitted for DHEC review and approval as part of the specific design effort performed prior to construction of a new enhanced cap. Caps will be graded consistent with previous designs and the design goals listed above.

Currently, three non-trench site areas require significant grading to achieve final topography. The first is the low area east of the current north and south ponds. The second is west of the north and south ponds where new water management features may be excavated. The third is on the southeast side of the site where a closure water management pond may be installed. In the first area, located directly east of the existing north and south ponds, CNS plans to fill parts of the existing low area with compacted soils. Most filling will occur on the east side of the low area, gently sloping the land surface to tie into existing grades on trenches to the east and thereby limiting the extent of water ponding. The north and south ponds and adjacent low areas will be combined into a single pond.

The second area is located west of the combined north/south ponds. Here, another pond or drainage conveyance may be built to receive overflow from the north/south ponds. The potential pond location is on CNS property outside the current controlled area. CNS may recommend adjusting disposal facility boundaries to encompass such water management features (Section 6.7).

The third area requiring significant grading is located on the southeast side of the site. At this location, CNS proposes to enlarge the current sediment detention pond to improve long-term management of runoff.

At closure, CNS anticipates that localized features such as trenches, ditches, and stockpiles will need to be properly closed and final graded.

The significant site grading activities discussed above and summarized in Table 6-12 involve excavating an estimated 180,000 yd^3 of material and filling 145,000 yd^3. The current balance of earth materials suggests there will be a slight surplus. Any surplus will likely be used in final grading of localized features or as part of final enhanced caps. The anticipated earthmoving projects and associated estimated volumes are included in Table 6-12 below. Costs are provided in Tables 6-11 and 6-13.

Table 6-12
Earthmoving Volumes

Site Location	Cut (yd^3)	Fill (yd^3)
West Pond	70,000	100,000
Southeast Pond	110,000	0
North of Phase 3 Cap	0	15,000
Topsoil	0	15,000
Trench 70 Road	0	15,000
Totals	180,000	145,000

6.2.2.3 Vegetation

The last phase of final site grading will be to place topsoil and plant vegetation, as required. Only 40 acres outside of enhanced cap areas are anticipated to require grass cover. CNS' estimate of topsoil volume is based on installing approximately three inches of topsoil. Topsoil and vegetation costs for enhanced caps are budgeted as part of cap construction. Vegetated acreage does not include pond areas, which will not be grassed.

Site areas will be seeded with a mix of Bahia and Rye, selected as hardy species that retard erosion and provide substantial transpiration. The seeded areas will be fertilized to ensure proper root establishment and continued growth. Table 6-13 summarizes costs of topsoiling and seeding for all site areas except enhanced caps. Enhanced cap vegetation costs are included in Table 6-10.

6.2.2.4 Estimate of Erosion Rates

An estimate of long-term erosion rates at the Barnwell site is provided below. This calculation is provided to demonstrate that CNS caps are of sufficient thickness to provide long-term waste cover. Erosion data can also be used to estimate sediment accumulation rates in site water management ponds.

The erosion calculation assumes completed disposal site with established grass cover and little or no bare soil. Given these conditions, CNS has selected the Universal Soil Loss Equation (USLE) to estimate erosion rate (USDA, 1978). The USLE is an empirical model commonly used to determine long-term average soil loss. This calculation does not consider the possibility of gully erosion, which may contribute to loss of cover thickness under certain degraded cover scenarios. For the flat slopes at CNS and grass cover, gully erosion should be rare.

The USLE model is represented by the following equation:

$$A = RKLSCP$$

Where
A = Soil Loss Rate (tons/acre/yr)
R = Rainfall Factor
K = Soil Erodibility Index
LS = Length Slope Factor
CP = Cover Practice Factor

Variables in the USLE equation are described below. The Rainfall Factor (R) represents the erosive effect of falling rainfall at the Barnwell site and is based on rainfall patterns for different regions of the country. An average annual value of 275 has been selected for the Barnwell site region (USDA, 1978). The soil erodibility factor (K) represents a soil's susceptibility to erosion. An average value of 0.20 was selected based on Soil Conservation Service (SCS) values for the soil series found at or near the Barnwell site and lab test data from local topsoils. The Length Slope factor (LS) incorporates the effect of slope and slope length on erosion. CNS assumes two different LS factors because surface grades for enhanced cap areas (~3% slopes) are typically steeper than other site areas (~0.5 to 1%). The LS values determined for enhanced cap areas and all other areas are 0.35 and 0.26, respectively. The combined Cover Practice (CP) factor represents cover quality (vegetation type and amount) and whether soil conservation practices are applied. CNS has selected a value of .003 to represent long-term cover conditions at the Barnwell site. This value assumes an established grass cover over 95 to 100% of the site. Using the values listed above, the Barnwell site's erosion rate (A) ranges from .04 to .06 tons/acre/year depending on surface slope.

At .06 tons/acre/year the average decrease in land surface each 100 years is 0.03 inches. At this rate, the six inches of topsoil covering all trenches will last much longer than 500 years, ensuring long-term protection of the critical components in the enhanced cap.

6.2.2.5 Site Grading and Vegetation Cost Summary

The estimated costs for CNS site grading activities are provided in Table 6-13.

Table 6-13
CNS Grading Costs

Site Final Grading and Contouring	Contractor	$180,675
	CNS Labor	$8,360
Vegetation	Contractor	$6,600
Land Surveying	Contractor	$13,200
Fee		$60,562
Total		$269,397

6.2.3 Permanent Trench Identification

Permanent identification of all completed trenches is required by license. Brass markers stamped with the trench number and placed in reinforced concrete are installed at each trench corner, and a granite information marker is placed within the boundaries of the trench near one end.

Permanent brass corner markers are installed after enhanced cap construction at locations established by the Barnwell site registered land surveyor. Until 1984, CNS used granite for trench corner markers. Since that time, CNS has used a reinforced concrete and brass marker design. Most original granite corner markers have been replaced with the new design as a result of enhanced cap construction on older trenches.

The granite information markers (headstones) will be approximately 30" x 16" x 4" thick. The following information will be etched or sandblasted into the stone:

LOW-LEVEL RADIOACTIVE WASTE Trench number Trench Length in Feet Trench Width in Feet Total Activity in Curies Total Amount of Source Material in Pounds Total Amount of Special Nuclear Material in Grams Volume of Waste in Cubic Feet Completion Date of Trench Operations

As with corner markers, each information marker is embedded into the ground.

During the Phase I closure period, CNS has budgeted to re-survey all trench corner locations and to re-establish site bench marks. This activity will serve to verify trench location records and field monuments. The costs for re-survey and information marker installation are provided in Table 6-14.

Table 6-14
Permanent Marker Installation

Trench Corner Land Survey	Contractor	$2,640
Marker Installation	CNS Labor	$11,000
	CNS Equipment	$4,400
	Trench information markers (100 @ $550 each)	$55,000
Fee		$21,182
Total		$94,222

6.2.4 Site Maintenance

CNS will continue the trench inspection and maintenance programs described in Section 3.2 during the 18 months projected to complete closure activities. Maintenance activities include grass cutting, fertilization, and seeding to maintain grass cover on completed trench areas. Erosion and other repairs (such as minor subsidence repair) will be made as required. These costs are listed in Table 6-15.

CNS has assumed that during the closure period there may be up to four instances where subcontractors are required to repair subsided areas on completed caps. To date, CNS has not identified any subsidences requiring immediate repair on completed enhanced caps. However, on areas without enhanced caps, CNS has routinely observed and documented subsidences. Historically, most subsidences have not exceeded 20 square feet, with many substantially smaller. To repair subsidence on completed enhanced cap, CNS will use its earthmoving personnel to uncover subsided areas and contractors to repair affected geomembrane and geosynthetic clay liner in the barrier layer of the enhanced cap. Cost to make this kind of repair is estimated in Table 6-15.

During the Closure period, CNS will continue to maintain site access roads and surface water drainage conveyances. These maintenance activities will be required because closure grading, in-region-only operations, and other related earthwork activities will take place on parts of the site, resulting in the potential for erosion, siltation, and roadway degradation. These costs are listed in Table 6-15.

Table 6-15
Site Maintenance Costs During Closure
(Annual Costs)

Routine Maintenance	CNS Labor	$48,340
	CNS Equipment	$159,605
	Contractor	$6,000
Subsidence Repair	Contractor	$20,000
Fee		$67,844
	Subtotal	$301,789
Building and Equipment Maintenance Cost During Closure (Annual Cost)		
CNS Labor		$68,640
Fee		$19,906
	Subtotal	$88,546
Total		$390,335

6.3 Records Storage Facility

CNS proposes to establish a facility at the Barnwell site for long-term storage of site records, and environmental and characterization samples, as appropriate.

6.3.1 Conceptual Design

The CNS vault or facility for storage of transfer records shall meet the requirements of several standards, including:

- ASME NQA-1 Basic Requirement 17 "Quality Assurance Records"
- NFPA 232 "Standard for the Protection of Records"
- ANSI/ASME N45.2.9 "Requirement for Collection, Storage, and Maintenance of Quality Assurance Records for Nuclear Power Plants"

No specific requirements for core and sample storage are assumed in the conceptual design, other than prevention of sample freezing.

Combined sample/core and records storage will be housed within an all-metal building, ensuring maximum longevity and minimal maintenance. Estimated building size is 40' by 80', with approximately 90% of the space dedicated to sample/core storage and office space and the remaining to records storage. The records storage area will be a 2-hr fire-rated vault.
Space is provided for the current and projected future amount of CNS core and environmental samples. Additional working space is provided for viewing and studying samples and for archiving future samples. Office space is also provided for management of record and sample archive systems and for processing and retrieval of records from the vault.

6.3.2 Records Facility Design and Construction Costs

Basic building cost (including electrical and lighting, heating, and plumbing) is conservatively estimated at $40 per square foot based on contractor bids and architect/engineer input. Finished office space is conservatively estimated at $60 per square foot. Total cost for the building (excluding records vault) is approximately $124,000. Cost for vault construction is estimated at $60,000 based on $150 per square foot provided by architect/engineer. Total estimated building construction cost is $211,600, including a 15% contingency.

CNS plans to use an architect/engineer to consolidate CNS, DHEC, and State archive specifications and develop a final building design. This effort will involve a scoping meeting and design review meeting. Cost for structure design and construction is provided in Table 6-16.

Table 6-16
Records Storage Facility

Building Design	Contractor CNS Labor	$34,500 $7,720
Construction	Contractor CNS Labor	$211,600 $7,000
Fee		$75,638
Total		$336,458

6.3.3 Proposed Facility Location

The facility is proposed to be located on CNS property adjacent to the southeast corner of the Barnwell site licensed disposal area. The proposed location provides easy access to the disposal area away from the current CNS campus area, and the facility can also be readily reached from county-maintained Osborn Road.

6.4 Survey Control

CNS uses a site grid system to accurately locate trenches, monitoring wells, and other site features. This system is tied to South Carolina Geodetic Survey benchmarks and to Savannah River Site (SRO) monuments, with SRO monument 128 serving as the origin location for the disposal site. The north direction for the site grid system parallels the west disposal area boundary.

Precise surveys documenting trench and monitoring well locations and elevations are needed to ensure compliance with license and other requirements. Surveys are required to ensure appropriate separation between adjacent disposal trenches and separation of trench bottoms from the water table.

CNS maintains five permanent benchmarks on the disposal site to facilitate survey work. Trench, monitoring well, and other critical surveys at the Barnwell site are performed by a registered land surveyor.

6.5 Site Monitoring

During the closure period, monitoring will continue with the same media, sampling frequencies, and analyses as the current programs (Section 3.4). CNS anticipates fewer monitoring points will be required. The closure period monitoring program is summarized below. Sampling costs include both radiological and non-radiological sampling.

Sumps will be checked quarterly for evidence of water intrusion into the trenches. Samples will be taken for gamma-emitting radionuclides and tritium analysis only when standing water is detected. No sumps are monitored as part of the non-radiological environmental monitoring program.

During closure, the non-radiological groundwater monitoring program will be continued. The non-radiological data are documented in quarterly non-radiological monitoring reports submitted to DHEC.

Sixteen points for surface soil and vegetation sampling will be defined for the closure monitoring program. Each sample point will be sampled quarterly for both media.

The water, soil, and vegetation samples described above will be analyzed for gamma-emitting radionuclides and tritium.

Air sampling using a particulate filter arrangement will continue in support of closure activities at the twelve site environmental stations. Every two weeks filters will be changed and filter media will be analyzed.

Environmental thermoluminescent dosimeters (TLDs) will be maintained and exchanged quarterly during the closure period. The existing program will continue through closure and may be adjusted for in-region-only operations.

Table 6-17 details the radiological and non-radiological monitoring programs planned for the closure period.

Table 6-17
Closure Period Monitoring Program

Sample Description	# Locations	Type	Collection Media	Frequency	Analysis
Wells[1,2]	120	Grab	Water	Quarterly	Gross alpha/beta, Gamma Isotopic, and Tritium
	28	Grab	Water	Quarterly	pH, Conductivity, Total Organic Carbon,Volatile Organics
	28	Grab	Water	Annually	Carbon-14
	16	Grab	Water	Annually	Acids, Base/Neutrals, Pesticides/PCB's, Phenols, Cyanide, Metals
Surface Water [3]	8	Grab	Water	Quarterly	Gross alpha/beta, Gamma Isotopic, and Tritium
	2	Grab	Water	Annually	Carbon-14
	2	Grab	Water	Quarterly	VOC, TOC
	2	Grab	Water	Annually	Acids, Base/Neutrals, Pesticides/PCBs, Phenols, Cyanide, Metals
Observation Sumps[2,4]	100	Grab	Water	Quarterly	Gamma Isotopic and Tritium
Surface Soil	16	Grab	Soil	Quarterly	Gamma Isotopic and Tritium
Sediment [3]	4	Grab	Sediment	Annually	Gamma Isotopic and Tritium
Samples of Opportunity[5]	500	Grab	Various	Various	Gross alpha/beta, Gamma Isotopic, and Tritium as needed.
Vegetation	16	Grab	Vegetation	Quarterly	Gamma Isotopic and Tritium
External Gamma	105	Contin uous	TLD	Quarterly	Exposure
Atmospheric	12	Contin uous	Particulate Filter	Every 2 Weeks	Gross Alpha/Beta, Gamma Isotopic,

(1) Includes selected wells from the existing monitoring programs.
(2) Water levels measured quarterly.
(3) Same locations as the current monitoring program.
(4) All sumps monitored for water accumulation with samples collected when available. As of 1/1/99, there are 129 sumps in the monitoring program.
(5) Samples deemed desirable. The number of locations represents the total number of samples collected annually.

Table 6-18 summarizes closure-period monitoring program costs. The table includes all labor and supplies for sampling and sample analysis using commercial vendor rates as the basis for determining analysis costs.

Table 6-18 Site Monitoring Costs During Closure (Annual)		
		Cost
Sample Collection	CNS Labor CNS Equipment	$98,800 $32,200
Stormwater	Contractor CNS Labor	$12,000 $640
Analyses-Radiological and Non-Radiological	Contractor	$455,714
Environmental Program Waste Disposal		$72,400
Fee		$194,809
Total		$866,563

These closure monitoring costs are based on DHEC acceptance of the closure groundwater monitoring program, which will be submitted prior to closure. Approximately 133 monitoring wells will be abandoned and sealed as part of closure. The estimated costs of these abandonment activities are listed in Table 6-19.

Table 6-19 Monitoring Well Abandonment Costs		
Monitoring Well Abandonment	CNS Labor Materials Contractor	$19,215 $20,192 $218,400
Fee		$74,764
Total		$332,571

6.5.1 Costs of Managing Environmental Program Wastes

As a result of the environmental monitoring program, radioactive waste will be generated that will require processing and disposal. The radioactive waste will be in two forms: water from the groundwater monitoring program and dry active waste from sample collection and analysis activities.

The guidelines for management of the water are summarized as follows:

- Purge water removed from environmental wells during sample collection having a concentration less than or equal to 50% of the

National Primary Drinking Water Standard Maximum Contaminant Level (MCL), will be discarded at the sample location. This applies to monitoring wells only. It does not include trench standpipes.

- The maximum volume to be discarded per well shall not exceed 50 gallons. Volume in excess of 50 gallons will be placed into a water management basin (such as the North Pond).

- Purge water having a tritium concentration greater than 50% of the MCL will be treated for disposal.

- The previous quarter's environmental data will be used to determine which wells fall into the save or discard categories.

- Water collected for analysis will also be managed by these criteria. Upon completion of the analyses, if the only nuclide present is tritium, and its concentration is less than or equal to 50% of the MCL, the sample water will be discarded in the "North Pond" or in an approved water management pond. If other nuclides are present or the tritium concentration is greater than 50% of the MCL, it will be treated and the residue will be returned to the disposal site for disposal. The current treatment of CNS choice is Thermex. Cost estimates provided assume Thermex treatment and site disposal.

- Water acquired during the construction and/or re-development of environmental monitoring wells will be analyzed on a case-by-case basis to determine tritium concentration. If the concentration is less than or equal to 50% of the MCL, the water will be placed into the "North Pond" or in an approved water management pond. If the concentration is greater than 50% of the MCL, it will be treated.

- All water collected from trench monitor pipes and sumps will be treated.

The annual volume of water produced by the environmental sampling program that would require treatment based on currently approved guidelines is approximately 4,400 gallons. Also, solid radioactive waste consisting of sampling supplies, protective clothing and sample residuals will be about three 55-gallon drums of dry active waste annually. The annual cost for managing this waste is estimated as $72,400 (see Table 6-18).

6.6 Performance Objectives Assessment

Near the end of the closure period, CNS will submit a comprehensive report evaluating compliance with site performance objectives. Each performance objective described in Section 9.0 will be evaluated. All objectives except Objective E have been addressed elsewhere in the closure plan. Demonstrating compliance with Objective E will require a site performance assessment. The steps in this analysis are described below.

At the time of site closure, CNS will evaluate environmental data. The average environmental data will be used to estimate peak dose rates to any member of the public at compliance locations. This evaluation will be conducted consistent with recent site performance evaluations (CNS, 2000b).

The most current average water level map and stream flow data will be used to calibrate the groundwater model. CNS will calculate groundwater pathlines and compare them to known locations of tritium, calibrating the model so calculated pathlines match tritium locations indicated by CNS environmental monitoring data.

Peak dose rates at a compliance point along Mary's Branch creek will be determined by:

- Evaluating radionuclide mobility by distribution coefficient data and by direct environmental monitoring data.
- Plotting stream tubes from wells showing elevated radionuclide concentration.
- Assigning the highest average radionuclide concentration obtained from sample points to the stream tube. Stream tubes intersecting several sample points will be assigned the highest average concentration of all sample points.
- Assigning flow rates to water entering Mary's Branch according to the results of the groundwater flow model and radionuclide concentration determined by the above method.

- Using a mixing cell stream transport model to calculate maximum concentration of radionuclides at the compliance point.

The peak dose rate calculation incorporates environmental monitoring data and evaluates the mobility and potential impact of radionuclides not observed in environmental data. It also estimates dose rates from potentially important radionuclides that may contribute to dose rates at compliance locations.

Finally, CNS will calculate peak hypothetical dose rates to a continuous consumer of water using dose conversion factors from DHEC Regulation 61-63, Part II, Appendix B, Table 2. Current peak dose rate calculations indicate continued compliance into the future.

CNS has not planned air pathway dose assessments, because airborne dose rates appear to be negligible based on current environmental monitoring measurements. CNS also assumes additional monitoring wells and/or characterization boreholes will not be required to complete final performance assessment studies.

Table 6-20 summarizes anticipated cost associated with evaluation of performance objectives. The cost estimate includes an additional $1,000,000, requested by DHEC, intended as a reserve for hiring contractors and peer review associated with site closure and performance assessment evaluations.

Table 6-20
Performance Objectives Evaluation

• Update Environmental Database • Update and Calibrate Site-Specific Groundwater Flow Model and Rerun Pathway Calculation • Calculate Maximum Concentration and Dose Rate • Document Results • Prepare Performance Objectives Evaluation Report	$1,000,000
• DHEC Assessment Reserve	$1,000,000
• Fee	$290,000
Total	$2,290,000

6.7 Property Boundary

CNS currently leases a 235-acre area from the state of South Carolina for use as a disposal site. At closure, CNS may recommend that property boundaries and designations be changed to reflect the best configuration for long-term management and monitoring of the disposal facility. To achieve these goals, CNS believes the size of state property may need to increase. Property boundaries may need to be adjusted to control future development, and allow access for long-term monitoring and remediation if necessary.

CNS property south of the disposal site extends to the headwaters of Mary's Branch of Lower Three Runs Creek, encompassing the groundwater pathway from disposal site trenches on state property to ground water discharge at the creek. At the time of site closure, CNS may recommend changing property ownership dependent upon the most recent radiological characterization of groundwater. Final property boundary will be determined with SCDHEC consensus.

Any adjustments to state property will be fenced during the closure period consistent with current controlled area fence standards. For estimation, CNS assumes approximately 4,200 feet of new fence. Fence costs are included in Table 6-21 below. General site security and fence inspection costs are addressed in Section 6.1.6.

Table 6-21
Fence and Property Boundary Relocation

Land Survey	Contractor	$6,800
Fence Relocation	Contract Labor	$11,106
	CNS Labor	$2,240
	Materials	$20,608
Fee		$11,819
Total		$52,573

6.8 Project Management and Other Closure Costs

During the Phase I closure period, CNS plans to assign a closure project management team. This team will be supported by certain corporate functions and will require certain infrastructure and equipment. These personnel are budgeted as part of closure. CNS has also budgeted in the Closure Plan for taxes, insurance, and fees that currently apply to the disposal site. Project management and associated costs are described in the following sections.

6.8.1 Project Management Team

The proposed organization chart for the Phase I closure project is shown in Figure 6-2. The personnel shown may be involved for part or all of the closure period, depending on the schedule of tasks and manpower loading. CNS has scheduled tasks to level workload for the 18-months required to complete closure tasks (see Section 6.10). Personnel costs, other than “Project Management Team” costs, are included in specific task budgets.

CNS plans to maintain the closure project management team full-time during closure. Management team costs are summarized in Table 6-22. This team will manage closure tasks, prepare documentation reports, communicate with DHEC on closure issues and provide personnel to address unforeseen issues.

Table 6-22 also includes corporate support costs such as quality assurance, financial controls support (e.g., billing, accounts payable, purchasing), human resources and information system support.

CNS also plans to provide incentive for CNS employees directly involved in closure to remain for the time their services are required. This will help retain quality, experienced CNS personnel to the end of closure.

Table 6-22
Project Management

Project Management Team	CNS Labor	$1,154,400
Corporate Support	CNS Labor	$453,960
Employee Incentive		$694,735
Fee		$667,898
Total		$2,970,993

6.8.2 Utilities, Taxes, and Fees

The disposal site and associated infrastructure incur utility costs, taxes, and insurance fees. CNS also anticipates that DHEC's disposal site licensing fees will continue through the closure period. During Phase I closure, CNS will continue to operate with costs of taxes, insurance and most license fees paid as an operating cost. A portion of utility and other general costs in direct support of closure are summarized in Table 6-23 below. The estimate does not cover surcharges for administrative costs of the South Carolina Public Service Commission, Atlantic Compact Commission, and Budget and Control Board, which are funded through waste receipts.

Table 6-23
Other Facility Costs
(Annual)

Utilities	$143,408
General Supplies and Materials	$100,000
DHEC Fees	$275,000
Fee	$70,588
Total	$588,996

6.9 On-Going Closure Activities

Throughout its history, CNS as a routine practice has performed maintenance actions and other site repairs to achieve and maintain site stability. In 1991, CNS started actual closure activities by constructing enhanced caps and establishing final closure topography. Each enhanced cap has been constructed to an approved final grade and contour to ensure long-term stability and adequate trench cover. Enhanced trench caps are discussed below and in section 6.2.1.

CNS plans to continue implementing closure activities during the next eight years (prior to the actual closure period). Closure activities will include completing additional enhanced cap construction on both old and recently completed trench areas and constructing closure water management features.

6.9.1 Completed and On-going Closure Activities

Since 1991, CNS has implemented closure activities paid for from the Decommissioning Trust Agreement Fund. The activities funded in this manner were primarily enhanced capping and performance assessment projects. CNS has implemented without fund support other decommissioning activities such as well and trench standpipe abandonment and Electro-Con Building characterization and decommissioning. Section 6.2.1 summarizes cap enhancement projects completed to date. Other completed or on-going activities are described below.

With DHEC approval in 1993, CNS implemented an extensive evaluation of the quality of trench standpipes with the goal of abandoning degraded and excess monitoring pipes. This evaluation has led to the abandonment of nearly 400 standpipes, leaving monitoring pipes only at key monitoring locations. CNS proposed this site improvement to remove redundant and ineffective monitoring points and to ensure minimum penetrations in the final trench caps. All evaluation and abandonment activities have been approved by and documentation provided to DHEC. The trench standpipe abandonment project was completed during 1997.

In the past, CNS has abandoned wells on a case-by-case basis, typically depending on well performance and location. Such wells include those coinciding with proposed trench locations and damaged wells that cannot be easily repaired. In 1994, a comprehensive groundwater monitoring plan for closure was developed. This report identified the total set of wells required for closure monitoring, recommending new wells and abandonment of others.

During 1995, CNS characterized and decommissioned the Electro-Con Building, a 30-foot square building located on the disposal site adjacent to the Site Operations Maintenance Building. This building was originally used for electro-polishing of small contaminated hardware. Decommissioning involved dismantling the building and foundation, removing shallow soils, and subsurface drilling and sampling to characterize surrounding groundwater quality.

CNS has recently implemented several closure performance assessment activities, including an evaluation of the feasibility of waste inventory reconstruction and state-of-the-art environmental monitoring and laboratory analysis. These tasks are anticipated to be complete during 2000.

6.9.2 Closure Activities (2000 – 2008)

Closure activities proposed for the next eight years are described, budgeted, and scheduled in the 2000 Least Cost Operating Plan (CNS, 2000a). Activities include (1) continued capping of older site areas as well as recently completed trenches, (2) constructing closure water management features on the west side of the disposal site, (3) developing an updated closure groundwater monitoring plan and continued abandonment of monitoring wells, (4) constructing a records storage facility, and (5) continuing closure performance assessment activities, as appropriate. These tasks are described below.

During the next eight years, CNS anticipates capping projects for four site areas identified as Proposed Phases 6, 7, 8, and 9 enhanced caps on CNS drawing B-500-D-300. Cap construction schedule and cost are provided in Table 6-10.

CNS plans to design and construct closure water management facilities on the west side of the disposal site during 2000 and 2001. Water ponding and active management have continued to increase as the capped area of the site increases. Final design will involve detailed pond design calculations, including full storm routing, pond capacity and spillway designs, and discharge permitting. Proposed final topography and surface water management are discussed in Section 6.2.2.

During 2002, CNS plans to design and construct a records storage facility for long-term archival of disposal records and storage of appropriate environmental and geological characterization samples. Details are provided in Section 6.3.

Based on the findings of on-going performance assessment studies, CNS plans to update its site closure groundwater monitoring plan. In Section 6.5 of this plan, CNS recommends and budgets for up to 120 wells for closure monitoring. As part of developing the closure groundwater-monitoring plan, CNS will select an appropriate network of wells and justify their use for long-term monitoring (see Section 8.6). CNS will abandon wells not part of the closure-monitoring plan.

CNS will complete on-going performance assessment studies as described in Section 6.9.1. Further studies may be required at closure. These are described in Section 6.6.

6.10 Closure Cost and Schedule

CNS has budgeted and scheduled for closure activities to occur during the next eight years of site operations as well as during the closure period. Implementing certain closure activities during operations makes efficient use of available manpower and resources, reducing manpower needs and cost of closure. Assumptions for the closure schedule and budget are that tasks scheduled over the next eight years are completed as planned and remaining work will occur during the closure period. The closure period will occur during the last two years of the 10-year planning period, concurrently with in-region-only operations. Site closure can be performed alongside in-region-only operations because the scale of in-region operations is anticipated to be minimal, and operations areas will be segregated from other site areas (CNS, 2000a).

All cost estimates are provided in 2000 dollars (unless otherwise noted). Closure cost and schedules are described in detail in the following sections.

6.10.1 Closure Manpower

For each individual closure task, CNS has estimated manpower and other resource requirements to complete work in an efficient and quality manner. These estimates and associated costs are provided in the respective Closure Plan sections. CNS has evaluated these manpower and resource needs and developed an overall schedule making efficient use of qualified personnel and available equipment.

To make efficient use of personnel and control closure costs, CNS has scheduled certain closure activities to occur during the next eight years of operations. Remaining closure period activities have been scheduled to allow a designated closure project team to complete this work in an orderly and efficient manner. This team is comprised of individuals with the necessary skills to perform all tasks anticipated to remain at closure. Team members will be qualified and cross-trained to support multiple functions. Figure 6-2 shows the personnel classifications comprising the closure project team. The schedule in Figure 6-3 has been developed to make efficient use of the project team, while avoiding manpower shortage. In certain cases of manpower shortage or unforeseen problems, CNS may need to hire temporary labor.

6.10.2 Closure Schedule

Figure 6-3 shows the detailed schedule of closure activities through Phase I closure. This schedule shows the next eight years of closure tasks, which are to be completed alongside normal operational activities, remaining closure period tasks, which will require approximately eighteen months to complete, and the post-closure observation period (discussed in Section 8.0). CNS plans to start the Phase I closure period at the beginning of in-region-only operations during year nine of the ten-year planning period. The schedule of DHEC closure approvals is provided in Table 7-1.

FIGURE 6-1

SITE TOPOGRAPHY AND WATER MANAGEMENT

(THIS FIGURE AVAILABLE IN SEPARATE ELECTRONIC FILE)

FIGURE 6-2

Closure Project Team

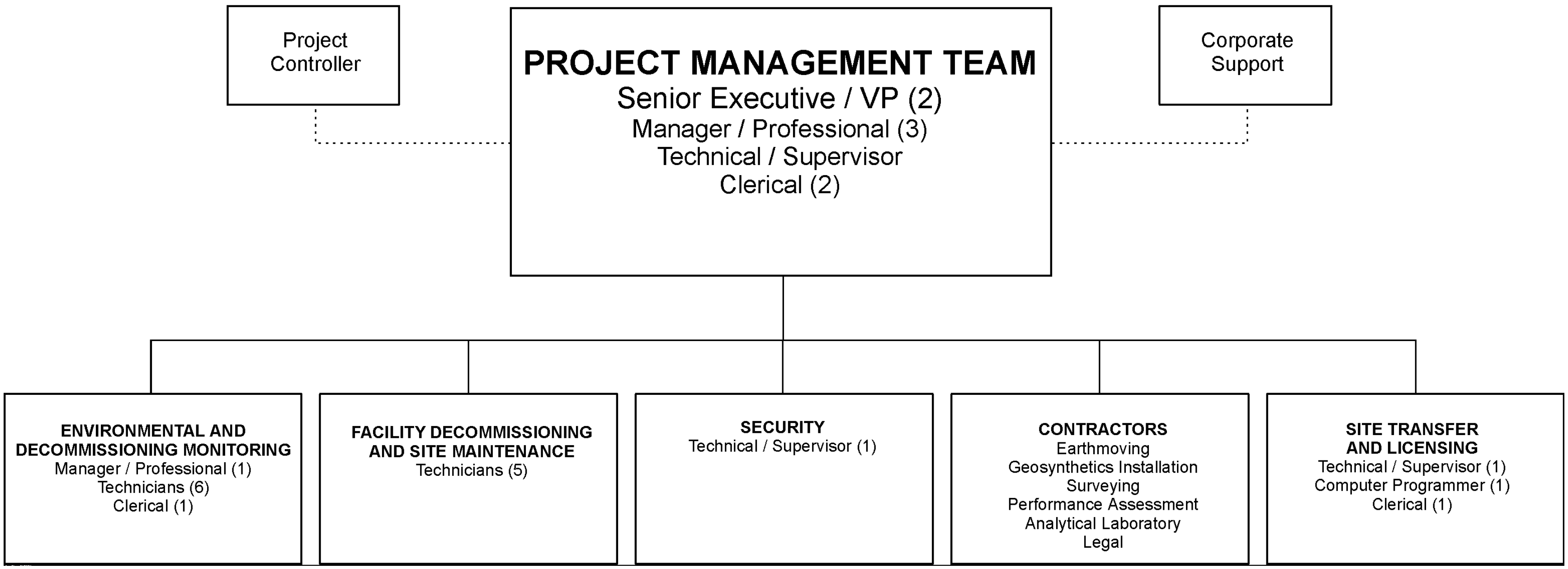

FIGURE 6-3

CLOSURE ACTIVITIES SCHEDULE

THIS FIGURE AVAILABLE IN SEPARATE ELECTRONIC FORM

6.10.3 Closure Cost Summary

Within the text of the Closure Plan, CNS has estimated cost for the individual tasks required for closure, as well as for on-going routine activities such as environmental monitoring, security and administrative functions. Cost contingency between 0 and 15% has been built into each estimate of closure activity direct costs, depending on CNS' confidence in the estimate. A summary of closure activity costs taken from the tables throughout Section 6.0 is provided in Table 6-24. This table also tracks the balance of the Decommissioning Trust Agreement Account to ensure sufficient funds to implement closure tasks.

CNS assumes for the purpose of projecting closure costs and schedule, that, after the eight-year period (2000-2008), the site goes into closure, concurrent with in-region only operations, and all remaining closure activities outside the area designated for in-region-only operations are performed during the closure period. CNS assumes closure activities will take 18 months of the two year period to complete. Closure activities scheduled for the closure period do not include those activities projected for completion during the preceding eight-year period.

Project management, general administrative functions, supplies, and fees are included on Table 6-24. These cost items ensure adequate funds for the project team, other fixed costs, and for appropriate corporate support functions. CNS corporate support functions include general management, accounting and finance, human resources, public affairs, legal, benefits administration and purchasing.

Some of the activity cost tables include direct equipment costs. CNS assumes that leased construction equipment will be used. CNS will use its equipment if possible; however, leased-equipment rates ensure conservative cost estimates. Equipment hours have been estimated based on the length of individual closure tasks.

Table 6-24 provides the financial schedule for decommissioning costs in 2000 dollars. Interest accrues to the fund and is added to the fund balance periodically. The rate of interest has ranged from 6-8% over the past few years. CNS has assumed a real increase in fund value of 3% annually based on recent fund performance history. This method eliminates the need to update closure activity costs in consideration of inflation. Based on the current amount in the decommissioning fund and the proposed funding plan, sufficient monies will be available to complete the activities discussed in this Closure Plan and outlined on the schedule.

TABLE 6-24
Insert excel table from Helene here (Decommissioning Costs Schedules Summary)

6.11 Financial Assurance

On March 24, 1981, CNS entered into a Trust Agreement with the State of South Carolina to provide monies to establish a site decommissioning fund. This fund will be used to complete the requirements of the Site Closure Plan. In 1981, at the time CNS entered into the Trust Agreement, CNS contributed a lump sum of approximately $1.7 million to the decommissioning fund. No additional contributions were made until April 1, 1993, when $4.11 per cubic foot of waste disposed at the Barnwell site was contributed to the fund. This contribution lasted for three months. Contributions were reinstated effective January 1, 1994, at $12.60 per cubic foot to cover costs of enhanced capping at the Barnwell site. On July 1, 1995, the contribution was reduced to the current $4.20 per cubic foot. CNS evaluates and makes recommendations regarding adequacy of fund balance and contribution rate during each Closure Plan update.

Based on the estimated costs to perform the remaining closure activities, the closure fund will contain sufficient funds to complete site decommissioning. Any remaining balance in the decommissioning fund will be used to pay post-closure observation maintenance and monitoring costs until the fund is depleted.

6.12 In-Region Operations (Phase II) Closure Period

CNS assumes 30 years of in-region-only operations. In-region-only operations will require the use for disposal of about three acres of the site, based on 240,000 ft^3 received over 30 years. Final Phase II closure will entail the following activities in Table 6-25.

Table 6-25 In-Region (Phase II) Closure Period Activities	
Enhanced Capping	$525,000
Facilities Decontamination	$35,000
Final Site Survey	$180,000
Final Performance Objectives Evaluation	1,000,000
Fee	$504,600
Total	$2,244,600

The in-region closure period is assumed to last about one year. Costs for these final closure activities are estimated at approximately $2.24 million (2000 dollars). This estimate assumes routine maintenance, monitoring, security and corporate support continue to be funded through the long-term care fund. CNS assumes in its evaluation of long-term care fund adequacy that all Phase II closure costs are paid for from the long-term care fund (see Section 8.8).

Enhanced caps to be installed for in-region operations trenches are assumed to be of the same design as current caps. It is also assumed that no caps are installed until the start of Phase II closure, although CNS anticipates cap will actually be installed as trench(es) are completed.

Facilities remaining to be surveyed and decontaminated will be the Cask Maintenance Building, Site Building, HP Building, Instrument Calibration Shop, Receiving Warehouse No. 3, and Drilling Equipment Storage Trailer.

CNS also budgets for a final site survey, which is assumed to cover both the in-region operations area and previous closed parts of the disposal site.

After 30 years of additional operations and observation of closed site areas, CNS expects most site performance issues will be resolved. However, CNS includes the cost of performance assessment and performance objectives evaluation to provide further documentation of site conditions and performance.

7.0 SITE TRANSFER TO CUSTODIAL AGENCY

This section describes the actions required to transfer the disposal site and its required relevant records to the State's custodial agency.

7.1 Transfer of Control & Responsibility

At the end of in-region operations when disposal operations at the Barnwell site cease, CNS will perform Phase II closure and post-closure observation, then transfer possession and control of the site to the custodial agency of the State of South Carolina. At the end of Phase I closure and post-closure observation, CNS will request DHEC concurrence that the site, except those areas designated for in-region operations, has been closed in a manner meeting performance objectives. This Closure Plan describes the activities that must be completed to effect Phase I closure and transition to in-region operations.

Upon completion of Phase I decommissioning activities, the Decommissioning Trust Agreement balance will be used to perform post-closure observation period maintenance and monitoring until expended. Thereafter, site monitoring and maintenance during in-region operations will be paid from the long-term care fund.

During the past few years, CNS has performed specific projects for site closure such as installing enhanced caps. DHEC approvals were obtained before these activities began and reimbursement has been received from the decommissioning fund after completion. CNS expects to continue this practice for remaining closure activities. This approach provides for effective use of CNS and DHEC technical personnel and allows sufficient review time for critical aspects of site closure. Table 7-1 lists the approvals that CNS has identified as necessary to proceed with Phase I closure activities during operations over the next ten years. The actual start dates for successor tasks on Table 7-1 will depend upon the completeness of each submittal and DHEC's satisfaction that the proposed activities will meet regulatory requirements.

CNS will prepare and submit a final Closure Plan during the year prior to closure (Table 7-1). As with previous Closure Plans, the final Closure Plan will document the closure activities completed to date and outline the remaining activities required for site decommissioning and closure. The final closure of the Barnwell site will take about 18 months. At the end of closure activities, CNS will monitor the site for approximately five years to give DHEC sufficient opportunity to determine that the requirements for closure have been met. Upon the satisfaction of DHEC, CNS will submit a final report of performance objectives evaluation to the custodial agency.

The administrative costs to prepare and coordinate the submittals to DHEC are budgeted as part of closure project management in Section 6.8.

Table 7-1
DHEC Phase I Closure Approvals

Request for Approval	Estimated Submittal Date	Successor Tasks	Successor Task Start Date
West Basin Design Report	June, 2000	Reconfigure West Water Basin	July, 2000
Stormwater Permit (West Basin)	June, 2000	Reconfigure West Water Basin	July, 2000
Closure Groundwater Monitoring Plan (Update)	Jan, 2002	Well Installation/Abandonment	Apr, 2002
Records Transfer Plan	Feb, 2002	Construct Records Building	Apr, 2002
Enhanced Cap Phase 6 Design Report	May, 2001	Phases 6 Enhanced Cap Construction	July, 2001
Enhanced Cap Phase 7 Design Report	May, 2003	Phase 7 Enhanced Cap Construction	July, 2003
Enhanced Cap Phase 8 Design Report	Nov, 2004	Phase 8 Enhanced Cap Construction	Jan, 2005
Final Closure Plan	Jan, 2008	Final Closure Activities	July, 2008
Enhanced Cap Phase 9 Design Report	May, 2007	Phase 9 Enhanced Cap Construction	July, 2007
Enhanced Cap Phase 10 and 11 Design Reports	Aug, 2009	Phase 10 and 11 Enhanced Caps Construction	Oct, 2009
SE Basin Design Report	March 2008	Construct Southeast Basin	July, 2008
Closed Site Property Boundary	Jan, 2008	Fence Relocation	July, 2008
Building D & D Plan	Jan, 2008	Construct D & D Trench	July, 2008
Site Survey Plan	Feb, 2010	Final Site HP Survey	Apr, 2010
Closure Activities Completion Notification	June, 2010	Post-Closure Observation Period	July, 2010
Performance Objectives Acceptance Criteria	June 2010	Performance Objectives Evaluation Report	June 2013
Performance Objectives Evaluation Report	June, 2015	DHEC Approval	

7.2 Transfer Records

As part of Phase I closure, CNS will identify, transfer, and provide storage for certain Barnwell site records for post-closure use by the State of South Carolina. In Section 7.2.2 of this plan, CNS has proposed a comprehensive list of records meeting license criteria for transfer. These records are primarily waste disposal, trench construction and maintenance, and environmental monitoring records. In Section 7.2.1, records routinely transmitted to DHEC as part of routine site operations are summarized. Section 6.3 describes the proposed facility for storing these records.

7.2.1 Records Routinely Transmitted to DHEC

Through normal operations and in accordance with license requirements, CNS routinely transmits certain records to DHEC, including Site Receipt and Burial Activity Reports and Environmental and Site Monitoring Reports. Site Receipt and Burial Activity Reports will no longer be produced after cessation of commercial burial operations. However, CNS will continue transmitting records of monitoring activities during the closure period. Routine reports are described below.

7.2.1.1 Waste Receipt Reports

The Site Receipt and Burial Activity Report, which is provided to DHEC monthly, consists of a combination of reports relating to the types and quantities of waste received for burial at the disposal site. These reports are generated using data taken directly from the Radioactive Shipment Manifest forms provided with incoming shipments. The following paragraphs describe the individual monthly reports comprising the Site Receipt and Burial Activity Report.

The report **Volume By Waste Description (Report No. 304)** provides a breakdown of waste volumes by category of waste. Total volume is divided into fuel cycle and non-fuel cycle waste volumes, which are then further categorized by individual waste type (resin, solidified liquid, etc.) and physical form (dewatered, solid, etc.). Volume, relative percentage, and activity for each category are provided.

The **Disposal By State Report (Report No. 301)** provides the total volume of waste disposed by state. The volumes are also broken out by specific waste generators within each state. Specific generator categories include: utility, government, university, hospital, industry, and other.

The **Volume Buried By State For SC DHEC (Report No. 306)** lists the total volume and volume percent of waste buried each month from individual states and volume percent by Compact.

The **Trench Recap (Report No. 204)** provides cumulative totals of waste activity (in millicuries), grams of SNM, source pounds, SNM packages, waste volumes and the opening and closing dates for each trench.

The **Summary of Isotopes Received (Report No. 305)** lists the monthly totals in millicuries of each radionuclide received for disposal.

The total volume of waste generated by each State for each month is displayed in the **Monthly Volume By State (Report No. 302).**

The volume received per month from the state of SC, the Southeast Compact, and other Compacts, and their relative percentages are shown in the **Volume and Escrow by Month Report (Report No. 308).** This report also indicates the remaining volume for the year, the cumulative volume disposed and the escrow account volume.

The **Reactor/Non-Reactor Volume By State Report (Report No. 307)** provides monthly and year-to-date waste disposal volumes for each utility. It also lists the state and compact the utility is located in.

The **Decay Report (Report No. 207)** is a running inventory of the twenty most common and abundant radionuclides received at the Barnwell site. The totals are updated monthly to include new waste activity and take into account radioactive decay. Details of this report are discussed in Section 2.6.

The **Reactor Allocation Report (Report No. 309)** provides waste data for utility-generated waste only. This report lists the utility and facility, state, compact, total volume buried by the facility by month and the cumulative yearly volume.

In addition to the printed reports described above, a computer diskette containing the arrival number, waste generator, receipt date, burial date, trench location code, waste code, waste class, total volume and activity, activity per nuclide, SNM grams and source pounds for each shipment is also provided to DHEC on a monthly basis. This report provides the disposal data for the given month as well as running totals for the year. The information is taken directly from the Radioactive Shipment Manifests provided with each shipment.

7.2.1.2 Waste Shipment Records

All waste shipment records are transferred to microfilm. Shipping records from the beginning of disposal operations have been microfilmed and copies sent to DHEC. These records will serve as a permanent record for materials received at Barnwell. CNS will continue the microfilming program through the site closure period until all the waste shipment documentation is microfilmed and transmitted to DHEC. After microfilming and approval by DHEC, CNS will discard waste shipment paper records.

7.2.1.3 Monitoring Reports

The Site and Environmental Monitoring Reports, which are submitted to DHEC on a quarterly basis, provide the results of sampling and radiological analysis for both on- and off-site monitoring. CNS also prepares a quarterly report documenting results of the Barnwell site non-radiological monitoring program.

7.2.2 Records to be Transferred at Closure

During the Phase I closure period, CNS will generate and transfer records and reports documenting completion of site closure activities and compliance with closure performance objectives. In addition, CNS will transfer the reports, records, and drawings required by license for use by the state and/or custodial agency. CNS provides in Table 7-2 a list of proposed transfer records. Table 7-2 lists record types, current formats and volumes, and License 097 reference basis. The estimated cost of preparation and transfer of these records is provided in Table 7-3.

The following subsections describe the record classifications identified in Table 7-2.

7.2.2.1 Waste Disposal Records

Waste disposal records are the single largest volume of records generated by CNS that are proposed for transfer. CNS proposes to assemble a complete transfer package of waste disposal records comprised of the following: waste disposal manifests, special waste form approvals, and other general correspondence regarding waste disposal. CNS also maintains an electronic database from which routine waste receipt reports are generated. One working copy of this database will be transferred at the end of Phase I closure.

TABLE 7-2: BARNWELL SITE CLOSURE TRANSFER RECORDS (3 PAGES)
THIS FIGURE AVAILABLE IN SEPARATE ELECTRONIC FORM

7.2.2.2 Trench Construction/Maintenance Records

Trench construction and maintenance records are primarily stored in either the trench history or site stabilization files. The trench construction and design records are contained in the Barnwell site trench history files. The record types in these files include proposed and as-built trench drawings, trench qualification reports, and construction inspection records. Trench and site maintenance records are currently maintained by the CNS Licensing Department in the site stabilization files.

7.2.2.3 Monitoring Program Records

Monitoring program records include radiological monitoring reports, non-radiological groundwater monitoring reports, water level reports and maintenance and construction records associated with sample point locations. The monitoring reports listed above are currently provided quarterly to DHEC. CNS will continue to provide the routine monitoring reports through the closure period. However, CNS proposes to transfer at the end of Phase I closure only the computer databases of groundwater monitoring and water level data.

7.2.2.4 Site Drawings

The drawings will consist of the complete set of site drawings including trench-specific proposed and as-built drawings, on-site and off-site environmental sampling locations, burial trench locations, ancillary facility locations, land survey control point documentation, site utility locations, site topography, and maximum water table surface configuration.

7.2.2.5 Trench Radiation Final Site Survey Report

At the completion of Phase I decommissioning activities, a complete radiological survey of the site will be performed to verify that surface soils are not contaminated and that direct gamma radiation levels are consistent with the background radiation levels of the region. A report of these surveys will be transferred to DHEC upon completion and will include the results of soil sampling, direct radiation measurements, and CNS' summary and evaluation of results.

7.2.2.6 Performance Assessment Records

Performance assessment records include groundwater modeling, site characterization, performance assessment reports and the site Closure Plan. These reports provide documentation to demonstrate compliance with performance objectives. CNS anticipates that a final performance objectives evaluation report will be generated and submitted during the Phase I post-closure observation period.

7.2.3 Transfer Records Management

CNS has identified two classes of records involved in the transfer process: transfer records and archive records. Transfer records are those records to be provided as working copies for DHEC and/or site custodian use. These records will be stored within an on-site records storage facility. Archive records are security copies of CNS transfer records classified as public and permanent. Archive records will be provided to the South Carolina Department of Archives and History at the time of site transfer. Archive records will be identified during the closure period by CNS, DHEC, and the SC Department of Archives and History.

CNS plans to maintain transfer records in paper, microfilm, or electronic format. Most documents will be maintained on microfilm. For microfilm and paper records, a computer database index will be developed for efficient record retrieval. Computer databases of waste disposal and environmental data will also be transferred.

7.2.3.1 Records Processing

Microfilm has a long history of successful information storage and retention, is an acceptable medium in a Court of Law, and will last 25 to more than 100 years depending on film type, handling, and storage conditions. Microfilm technology is well accepted, standards are well-developed, and technologies for electronic indexing and transfer of microfilmed records to electronic media are in common use.

CNS proposes use of silver microfilm to store working copies of CNS records. Its life is typically 100 years, longer with careful handling. These records will be stored under controlled environmental conditions to maximize longevity. An electronic indexing system will be developed to ensure rapid retrieval of information.

Some records due to size, format, or condition may not be suitable to be microfilmed. These will be stored in their original format.

Storing data on microfilm requires document filming, film processing, and a reader/printer to access records. CNS plans to continue filming its records, using CNS personnel to film and a contractor to develop the film, until site closure. After transfer of records, CNS recommends that subsequent records be filmed and processed by a certified laboratory. A microfilm digitizing system will be used for viewing, printing, and converting records to electronic format. This system will be installed in the Barnwell records facility (see Section 6.3). The facility will not be designed to facilitate filming or processing.

7.2.3.2 Records Storage, Maintenance, and Recovery

Any record storage system depends on establishing and implementing proper process controls to protect and maintain data integrity. CNS will establish procedures and processes to address the following issues:

- records preparation and filming,
- legibility of filmed records,
- proper identification of records filmed,
- indexing, and
- long-term handling and inspection.

South Carolina regulation R12-202 specifies optimal storage conditions for long-term storage of microfilm. CNS currently uses an off-site storage facility that meets the requirements of this regulation. CNS plans to continue using such a facility for archive records until the time of site transfer. CNS will store its working copies in accordance with ANSI Standard PH1.43.1985, *Processed Safety Film Storage*, to maximize longevity of the working copies of microfilm. Storage criteria are summarized below:

ENVIRONMENTAL CONDITIONS FOR MICROFILM STORAGE		
	Archive-Quality Microfilm (required)	Working Copies of Microfilm (Recommended)
Maximum Storage Temperature	21°C (70°F)	25°C (77°F)
Relative Humidity	30 to 50%	30 to 60%

7.2.3.3 Records Management Cost Estimate

Records management costs include costs of a microfilm reader/printer/digitizer; professional support for installation and training; and personnel costs for evaluating current microfilm, converting existing paper records to film, and developing records management procedures and indexing system. Cost is summarized in Table 7-3. Existing records not currently microfilmed will be converted to microfilm. Labor will be required to organize, film, and index these records. Additional costs will be incurred by contractors to develop the film and for filming and processing of unusual record formats such as Barnwell site drawings.

Table 7-3
Records Transfer Costs

CNS Labor	$175,032
Contractor	$6,105
Equipment	$17,644
Fee	$57,646
Total	$256,427

8.0 POST-CLOSURE OBSERVATION AND LONG-TERM CARE

CNS describes in this section the post-closure and long-term care periods. The first five years after completion of Phase I and II closure periods involves the observation and monitoring required to ensure closure is complete and performance objectives are met. This plan outlines the overall site monitoring and maintenance program for the five years of post-closure following each closure phase and 100-years of institutional control. Possible remedial actions are identified and considered in an evaluation of the adequacy of the long-term care fund. CNS evaluates long-term care fund adequacy assuming funding of both post-closure observation and long-term care from the long-term care fund.

During the post-closure observation period and long-term care period, essentially the same manpower will be required. The five years of observation will entail primarily monitoring and maintenance. Funding is provided for site performance evaluations as may be required near the end of the observation period. Final review of monitoring data and performance evaluations will enable CNS and DHEC to verify conformance to the performance objectives.

The long-term care period has been divided into four stages: Stage I, which coincides with the thirty-six year in-region period (encompassing in-region operations, Phase II closure, and Phase II post-closure observation); Stage II, the first 25-years of institutional control; Stage III, the second 25-year period; and Stage IV, the remaining 50-years of institutional control. Results from a site performance evaluation following each of the first three stages will determine whether monitoring and oversight can be reduced for subsequent periods of long-term care.

The maintenance activities specified in this plan assume a closed, stable site, entirely covered in grass. CNS also assumes hiring contracted labor for any remediation.

CNS' evaluation of the long-term care fund assumes no decrease in level of monitoring and maintenance during the entire long-term care period. As a further justification of fund adequacy, CNS also looked at worst-case remediation scenarios.

8.1 Post-Closure and Long-Term Care Staff and Support

CNS proposes a staff of one supervisor, three technicians, and one clerical located at or near the disposal site to perform routine monitoring and maintenance work. The technicians will be qualified to operate the equipment needed to maintain the site grass cover, drainage conveyances and access roads. They will be trained to collect monitoring data and samples. At least one member of the staff will be qualified as a health physics technician, and one will have background in equipment maintenance. At least one individual on staff will be familiar with the records maintenance facility and have the knowledge to retrieve records. CNS recommends contracting with a qualified laboratory for sample analyses.

CNS assumes that a post-closure and custodial long-term care staff will incur indirect costs for support activities such as data and site performance evaluation, quality assurance, financial control, information systems and human resource support. Corporate management will provide project oversight. Staff will also require general supplies and materials (e.g. office supplies, tools, etc). CNS also assumes the custodial contractor will require a fee for services. These costs are summarized in Table 8-1.

Table 8-1
Long-Term Care and Post-Closure Observation Staff Annual Costs

	Post Closure	Long-Term Care
Direct Labor	$312,000	$312,000
Support Labor / Fee	$408,648	$378,501
Supplies / Materials	$10,000	$10,000
Total	$730,648	$700,501

8.2 Site Maintenance

Disposal area maintenance will be required during post-closure and the 100-year institutional care period. In long-term care, CNS expects maintenance requirements will decrease over time. In projecting long-term care fund adequacy, CNS assumes no decrease in maintenance and monitoring costs during institutional control.

During Stage I and II of long-term care (the first 36 and 25 year periods, respectively), maintenance such as mowing, fertilizing, road grading, repair of erosion and occasional localized trench subsidence will be required. Re-topsoiling and seeding will be performed, as required. Monthly inspections of trench cap integrity should be performed to ensure early detection of trench cap degradation and other site maintenance needs. Frequency of inspections may be varied according to observed site stability. Grass mowing on trench caps and surrounding areas will be necessary to maintain healthy grass stands and prevent growth of shrubs and trees. Security fence inspections must also be conducted and repairs made.

The equipment necessary to maintain the site is listed in Table 8-2. Table 8-2 includes anticipated equipment life, number of replacement units required and a calculation of annualized capital and maintenance costs. It is expected that mechanical repairs and service will be performed by a qualified local service. In long-term care fund projections, no equipment purchases are projected during the post-closure observation periods.

Table 8-2

Long-Term Care Equipment Costs

Item	Cost Per Unit	Replacement (yrs)	# of Units Over 100 Years	Total Cost
Backhoe Loader	$57,000	20	5	$285,000
Motor Grader	$200,000	20	5	$1,000,000
Pickup	$25,000	10	10	$250,000
Farm Tractor	$25,000	10	10	$250,000
Mower	$4,000	5	20	$80,000
Spreader	$2,000	5	20	$40,000
Total				$1,905,000
Annual Capital Cost				$19,050
Annual Equipment Maintenance & Fuel				$80,000
Annual Total				~$100,000

The required work for Stage III (the second 25-year period of institutional control) will decrease due to anticipated further stabilization of trench caps. Required maintenance will consist of quarterly trench cap inspections and the repair of erosion and settling detected during these inspections. The perimeter fence will be inspected quarterly and repaired if necessary. Grass mowing will continue to prevent growth of undesirable vegetation. Equipment needs will be the same as the first 25 years.

During Stage IV (the last 50 years) of long-term care, site maintenance should be significantly reduced. The inspection and repair of erosion caused by normal run-off will continue semi-annually. It is expected that grass mowing and fence repairs will be done on a quarterly basis. Although required maintenance will probably decrease, the annual equipment costs are conservatively assumed to be the same as earlier phases.

Enhanced caps may require repair if subsidence or large settlements occur. Repair will involve removing cap components down to the geomembrane. Then, if the geomembrane is severely strained, failed, or below adequate grade, the substandard portion of the geomembrane will be removed and the underlying bentonite mat inspected and replaced, if necessary. Both geomembrane and bentonite will be repaired in accordance with the same quality assurance/quality control procedures used during original installation.

Such repair will require a geomembrane installation contractor and quality assurance consultant. CNS estimates cost for cap repair assuming one-half acre of repair every five years through post-closure and long-term care. This will result in a cost of about $75,000 every five years, or an average annual cost of $15,000.

The personnel and equipment to perform site maintenance and monitoring during the long-term care period have been identified in Section 8.1. The staff size and equipment have been selected to accomplish the expected site maintenance including trench repairs from subsidence, general maintenance of access roads, upkeep of the buildings, equipment and security fencing, and maintenance of the drainage ways and surface water management basins. This staff will also collect samples for the monitoring programs.

CNS also assumes that approximately every 25 years during long-term care all fence will need to be replaced. Costs are provided in Table 8-3 below.

Table 8-3 Fence Replacement (per event)		
Fence Replacement	Labor	$42,080
	Materials	$78,080
	Survey Contractor	$6,000
Total		$126,160
Annualized Cost		$5,046

8.3 Other Facility Operating Costs

During long-term care, the facility may incur costs due to taxes, insurance, and utility costs. CNS anticipates incurring costs for property and real estate tax and property insurance. The custodian will also have to pay utility costs for the support facilities at the site. Long-term care and post-closure costs are summarized in Table 8-4.

Table 8-4 Annual Long-Term Care and Post-Closure Observation Facility Operational Costs	
Taxes	$69,060
Insurance	$23,208
Utilities	$50,000
Total	$142,268

8.4 Long-Term Site Performance Evaluations

Near the end of each post-closure observation period, CNS assumes a performance evaluation will be required. Also, at the end of each long-term care period phase, CNS recommends another evaluation of site performance objectives. The evaluations during long-term care, would entail review of current environmental monitoring data, site maintenance records, and current site topographic data to determine whether levels of monitoring and maintenance should be modified for the subsequent phase or, at the end of long-term care, to determine proper final site disposition.

CNS envisions hiring consultants to review environmental data and perform site performance assessment. Part of this effort would include a site HP survey (comparable to the final site survey in closure), topographic survey and other remote sensing, as appropriate.

Each evaluation will supplement the routine regulatory oversight and evaluation by DHEC, custodial monitoring, and every-five-year aerial site topographic survey and aerial photography. Topographic land survey and photographs will be compared against previous data to check general erosion rates, silt accumulation in the water management basins, and surface runoff flow patterns. Unusual data or inspection findings during routine oversight may require consultant support. Post-closure performance evaluation costs are summarized in Table 8-5. Long-term site performance evaluation costs are summarized in Table 8-6. CNS shows a decrease in cost of DHEC oversight during long-term care.

Table 8-5

Post-Closure Site Performance Evaluation Annualized Costs

Site Radiation Survey (1 event)	$40,000
Aerial Survey/Remote (once every 5 years)	$3,000
Performance Evaluation (1 event)	$200,000
DHEC Oversight	$675,000
Annual Total	$918,000

Table 8-6

Long-Term Care Site Performance Evaluation Annualized Costs

Site Radiation Survey (3 events)	$6,000
Aerial Survey/Remote (once every 5 years)	$3,000
Performance Evaluation (3 events)	$30,000
DHEC Oversight	$275,100
Annual Total	$314,100

8.5 Potential Long-Term Remedial Actions

CNS recommends budgeting for two potential remediation scenarios during the long-term care period. One involves pumping and treating groundwater near the headwaters of Mary's Branch to remove unacceptable levels of groundwater contamination. The other involves replacing enhanced cap on the disposal site. Both are not expected to occur, but provide a reasonable means to evaluate adequacy of the long-term care fund.

8.5.1 Pump-and Treat Scenario

CNS has measured tritium in Mary's Branch creek and evaluated potential dose rates to an off-site individual. CNS has also measured low concentrations of carbon-14 in groundwater beneath the stream. Since there is no known user of water at the location where the stream crosses the CNS property boundary, there is no measurable dose rate to an off-site individual immediately downstream of the Barnwell site.

Should levels of tritium become sufficiently large during the institutional control period, the site custodian and DHEC may find it necessary to treat groundwater before it enters Mary's Branch creek. A typical pump and treat system would be composed of a line of extraction wells perpendicular to groundwater flow, placed and designed to capture the highest level of radioactivity. Using these wells, water containing tritium and carbon-14 can be extracted and evaporated. The quantity of water removed can be controlled to manage stream concentration levels.

Treatment costs depend upon volumetric flow rate. Using baseline information from Fulbright et al., 1996, a plant treating 25 gpm of tritiated water will cost $17 million over 20 years (in 1996 dollars).

Based on recent environmental monitoring data, CNS may need to treat approximately 8.3 gpm to eliminate areas of high tritium groundwater entering Mary's Branch. The cost of treating this water is seven million over 20 years, assuming that treatment plant costs are directly proportional to volumetric flow rate. If CNS plans to treat all waters associated with the projected tritium plume, the required treatment volumetric flow rate is approximately 44 gpm, and the cost over 20 years is $30 million. CNS has used the conservative figure of $30 million in its evaluation of long-term care fund adequacy.

8.5.2 Cap Replacement Scenario

Long-term enhanced cap degradation, excessive settlements, or desirable new capping technologies may lead to a decision to replace or upgrade a large part of or all enhanced caps at the Barnwell site. Costs for this scenario are described below.

CNS envisions a cap upgrade/repair would involve excavation down to the geomembrane liner, and segregation of cover component materials for later re-use. Cap barrier components (clay liner, bentonite mat, and geomembrane) would be replaced or enhanced, and overlying cover components would then be reinstalled. To be conservative, CNS estimates that remedial cap replacement/enhancement would cost as much as $150,000/acre, comparable to the price of recent cap enhancement projects. Assuming total cap enhancement acreage at 125 acres, total site cap replacement would cost $18.75 million.

8.6 Site Monitoring

Proposed monitoring programs for the long-term care period emphasize groundwater monitoring. Based on the site's expected performance and the fact that the amount of radioactivity will be decreasing, CNS expects the program can be reduced during institutional control at the 25 and 50-year points. This possibility will be evaluated during the periodic site performance evaluations. CNS cost estimates assume no decrease in monitoring during the entire long-term care period. For cost estimate purposes, CNS assumes that long-term monitoring costs are the same as closure monitoring cost, therefore, annual cost for long-term monitoring is estimated at $468,514 ($455,714 for analyses and $12,800 for sampling supplies). Monitoring program details are provided below.

8.6.1 Radiological Monitoring

The long-term care and post-closure observation environmental monitoring program is summarized in Table 8-7. Data from the environmental monitoring program provides CNS with long-term trends, areal extent, and concentration of radioactivity in migration.

Additionally, CNS has analyzed and attempted to measure potentially mobile radionuclides in groundwater and air. Environmental and characterization data trends show the following:

- Tritium appears to be associated with most low-level radioactive waste trenches and migrates with groundwater.
- The highest tritium concentrations appear to be decreasing.
- Low concentrations of carbon-14 are measured downgradient of the disposal site.
- Other than tritium and carbon-14, there appears to be no other radionuclide migration with groundwater.
- There is no detectable quantity of gaseous phase radionuclides.

Based on these identified trends and knowing that radioactivity will decrease with time, CNS proposes to decrease the number of monitoring points during Phase I site closure. For post-closure monitoring, CNS recommends continuing monitoring at approximately site closure levels.

For planning purposes, CNS assumes 120 monitoring wells will be retained for post-closure and long-term care monitoring. Four stream locations have been selected on Mary's Branch; each location will be sampled quarterly for surface water and annually for sediment. Trench standpipes/sumps will be sampled quarterly. Surface soil samples will also be collected quarterly at selected boundary, on-site and off-site locations.

Monitoring locations will be chosen from the set of current monitoring locations. The majority of monitoring locations will be located within the disposal area and downgradient from the disposal site. The sample locations will be chosen so most areas on and downgradient of the disposal site will be sampled. Final locations will be chosen with SCDHEC concurrence.

Carbon-14 will be analyzed annually in nonradiological monitoring program wells. CNS will use gross beta as a surrogate measure of carbon-14 in groundwater for the remaining quarters.

8.6.2 Non-Radiological Monitoring

In addition to radiological groundwater monitoring, during the post-closure and long-term care periods, non-radiological groundwater monitoring will continue as shown on Table 8-7. This level of monitoring is comparable to that recommended during the Phase I closure period in Section 6.5. The sampling frequency may be reduced at later phases. A reduction in the frequency of sampling is justified by long-term trends of non-radiological constituents having the potential to migrate in groundwater. Volatile organic compounds have been identified in monitoring wells downgradient from the Barnwell site. Trend analysis forms submitted to DHEC on a quarterly basis indicate that non-radiological constituents in groundwater have remained relatively constant in concentration over the last three to five years, with no new compounds identified. Therefore, monitoring will be performance monitoring and not detection monitoring. Since the parameters are well documented, the frequency of monitoring could be reduced and still provide adequate information on constituent concentrations (NRC, 1989).

Table 8-7
Long-Term Care Monitoring Program

Phase I					
Sample Description	Locations	Type	Media	Frequency	Analysis
Wells (1,2)	120	Grab	Water	Quarterly	Gross-Alpha-Beta, Gamma Isotopic and Tritium
Wells (1,2)	28	Grab	Water	Annually	Carbon-14
	28	Grab	Water	Quarterly	pH, Conductivity, Total Organic Carbon, Volatile Organics
Wells (1,2)	16	Grab	Water	Annually	Acids, Base/Neutrals, Pesticides/PCB's, Phenols, Cyanide, Metals
Surface Water (3)	2	Grab	Water	Annually	Carbon-14
Surface Water (3)	4	Grab	Water	Quarterly	Gamma Isotopic and Tritium
Surface Water (3)	2	Grab	Water	Quarterly	pH, Conductivity, Total Organic Carbon, Volatile Organics
Surface Water (3)	2	Grab	Water	Annually	Acid, Base/Neutrals, Pesticides/PCB's, Phenols, Cyanide, Metals
Observation Sumps (2, 4)	100	Grab	Water	Quarterly	Gamma Isotopic and Tritium
Surface Soil	20	Grab	Soil	Quarterly	Gamma Isotopic and Tritium
Sediment (3)	4	Grab	Sediment	Annually	Gamma Isotopic and Tritium
Samples of Opportunity (5)	100	Grab	Various	Quarterly	Gamma Isotopic and Tritium

Notes:
(1) Includes selected wells from the existing monitoring programs annually.
(2) Water levels measured quarterly.
(3) Subset of current locations as the current monitoring program.
(4) Sump samples are collected when water is available.
(5) Samples deemed desirable by custodian.

8.6.3 Managing Environmental Program Wastes

As a result of the environmental monitoring program, radioactive waste will be generated that will require processing and disposal. The radioactive waste will be in two forms: water from the groundwater monitoring program and dry active waste from sample collection and analysis activities.

The guidelines for management of the water are summarized as follows:

- Purge water removed from environmental wells during sample collection that has a concentration of tritium less than or equal to 50% of the National Primary Drinking Water Standard Maximum Contaminant Level (MCL), will be discarded at the sample location. This applies to monitoring wells only. It does not include trench standpipes.

- The maximum volume to be discarded per well shall not exceed 50 gallons. If the volume exceeds 50 gallons, the volume above 50 gallons will be placed into a water management basin (such as the North Pond).

- Purge water with a concentration of tritium greater than 50% of the MCL will be treated for disposal.

- The previous quarter's environmental data will be used to determine which wells fall into the save or discard categories.

- Water collected for analysis will also be managed by these criteria. Upon completion of the analyses, if the only nuclide present is tritium, and its concentration is less than or equal to 50% of the MCL, the sample water will be discarded in the "North Pond" or in an approved water management pond. If other nuclides are present or if the tritium concentration is greater than 50% of the MCL, it will be treated and the remaining residue will be sent for processing and disposal. The current treatment of CNS choice is Thermex. Cost estimates provided assume Thermex treatment.

- Water acquired during the construction and/or re-development of environmental monitoring wells will be analyzed on a case-by-case basis to determine tritium concentration. If the concentration is less than or equal to 50% of the MCL, the water will be placed into the "North Pond" or in an approved water management pond. If the concentration is greater than 50% of the MCL, it will be treated.

- All water collected from trench monitor pipes and sumps will be treated.

The annual volume of water produced by the environmental sampling program that would require treatment based on currently approved guidelines is approximately 4400 gallons. Also, the solid radioactive waste consisting of sampling supplies, protective clothing and sample residuals will be about three 55- gallon drums of dry active waste annually. The annual long-term cost of processing, transport, and disposal is estimated at $147,400. While disposal site remains available for disposal of this waste, CNS estimates cost at $72,400 per year.

8.7 Post-Closure Observation and Long-Term Care Cost & Schedule

Post-closure observation and long-term care period site maintenance and monitoring activities and associated costs have been discussed in the preceding parts of Section 8. Table 8-8 and 8-9 summarize annual costs for Phase I post-closure and long-term care, respectively. CNS estimates annual cost of Phase II post-closure observation at approximately $75,000 more than Phase I due to additional costs of managing environmental program wastes. Likewise, the annual impact to the long-term care fund during in-region operations is approximately $100,000 less than institutional control primarily due to reduced cost of disposing environmental monitoring program waste during operational years. These assumptions are described further in Section 8.8. These tables do not include potential costs of remedial actions (see section 8.5), but do assume periodic partial replacement and repair of enhanced caps.

The long-term care fund (assuming balance at end of eight years of operations) will provide enough in annual interest to pay for Barnwell site long-term care. Based on the current fund balance, CNS estimates the fund could grow to as much as 300 million dollars during the 100 years of institutional control, even with annual expenditures projected above.

CNS has also evaluated the worst-case financial impact of remedial action. CNS assumed total cost of the two potential remedial actions (pump-and-treat and cap replacement) discussed in Section 8.5 would be deducted from the long-term care fund balance during institutional control. For this case, fund balance at the end of 100-years is approximately $22 million (see Figure 8-1).

Table 8-8
Average Annual Phase I Post-Closure Costs

Labor	$312,000
Corporate Support / Fee/Supplies	$418,648
Equipment Purchase	$0
Building and Equipment Maintenance and Service	$80,000
Enhanced Cap Liner Repair	$15,000
Land Survey (every five years)	$3,000
Fence Replacement (every 25 years)	$0
Rad and Nonrad Sample Analysis	$468,514
Radwaste Processing	$72,400
Site Radiation Surveys (1 event)	$40,000
Performance Assessment Evaluation (1 event)	$200,000
DHEC Oversight	$675,000
Facility Operation Costs (utilities, taxes, insurance)	$142,268
Subtotal	$2,426,830
Contingency (5%)	$121,341
Total	$2,548,171

Table 8-9
Average Annual Long-Term Care Costs

Function	Costs
Labor	$312,000
Corporate Support / Fee/Supplies	$388,501
Equipment Purchase	$20,000
Building and Equipment Maintenance and Service	$80,000
Enhanced Cap Liner Repair	$15,000
Land Survey (every five years)	$3,000
Fence Replacement (every 25 years)	$5,046
Rad and Nonrad Sample Analysis	$468,514
Radwaste Transport and Disposal	$147,400
Site Radiation Surveys (3 events)	$6,000
Performance Assessment Evaluation (3 events)	$30,000
DHEC Oversight	$275,100
Facility Operation Costs (utilities, taxes, insurance)	$142,268
Subtotal	$1,892,829
Contingency (5%)	$94,641
Total	$1,987,470

8.8 Financial Assurance

Chem-Nuclear entered into a 99-year Lease Agreement with the State of South Carolina on April 21, 1971, to lease a 17.2 acre plot of land, previously deeded to the State by Chem-Nuclear for the purpose of burial of radioactive waste. Under this agreement, Chem-Nuclear agreed to operate in accordance with its license application, the conditions of its License 097 and the requirements of the AEC (now NRC) and the State. The agreement also established a fund for the long-term care of the site. Chem-Nuclear agreed to pay eight cents into the fund for every cubic foot of waste received for burial.

A second Lease Agreement was executed on April 6, 1976, replacing the previous agreement and expanding the lease area to its present 235 acres; the other conditions of the lease remained substantially the same. However, the long-term care fund payment was increased to sixteen cents per cubic foot. The lease agreement was amended on September 11, 1979, to change the long-term care fund payment to fifty-five cents per cubic foot from September 1, 1979, through April 5, 1980; seventy-five cents per cubic foot from April 6, 1980, through April

5, 1981, and one dollar per cubic foot from April 6, 1981, through April 5, 1982. Payments after April 5, 1982, have been established through negotiations between Chem-Nuclear and the State. Pursuant to those negotiations, the agreement was again amended to stipulate a payment to the long-term care fund of two dollars per cubic foot from April 6, 1982, through April 5, 1983; two and one quarter dollars per cubic foot from April 6, 1983, through April 5, 1984; and two and one half dollars per cubic foot from April 6, 1984, through April 5, 1985. The current rate of payment was set on April 5, 1985 at $2.80 per cubic foot of waste. As of July 1, 2000, the fund contains approximately $96 million.

Section 8.0 of the Closure Plan provides updated information on the planned activities required to provide surveillance and maintenance of the buried radioactive waste. Based on the estimated costs to perform these activities, the long-term care fund contains sufficient funds to pay for these activities well beyond post-closure and through 100-year institutional control.

CNS based its long-term care fund balance projection on the following assumptions:

- Beginning fund balance of $95.8 million as of July 1, 2000.
- Thirty-eight years of continued operations at waste volumes projected in the 2000 Closure Plan and contribution rate of $2.80 per cubic foot. CNS assumes no withdrawals from the fund during the first ten years of operations.
- Two years of Phase I closure period during which CNS makes no withdrawals from the long-term care fund. Decommissioning fund is sufficient for 18-months of closure activities with sufficient funds remaining (approximately $800,000 from Table 6-24) to cover maintenance and monitoring during the last six months of the two-year Phase I closure.
- Five years of post-closure observation (Phase I) during which costs of maintenance and monitoring (Table 8-8) are withdrawn from the long-term care fund.
- Following post-closure, 23 years of long-term monitoring and maintenance withdrawn from long-term care fund, comprising remaining in-region operations period. Each year, CNS will withdraw $1,870,920, which is the long-term care figure in Table 8-9, less the annual cost of performance assessment, closed-site survey, and environmental monitoring waste disposal.

- One year of Phase II closure with costs withdrawn from long-term care fund. Total cost for one year is $4,366,922, combining closure costs in Table 8-8 and maintenance and monitoring costs for Phase II post-closure.
- Five years of post-closure observation (Phase II) withdrawn from long-term care at $2,626,922 per year, which is post-closure cost provided in Table 8-8, plus the potential cost of environmental monitoring program waste disposal.
- One hundred years of institutional control, annual cost provided in Table 8-9.
- Long-term care fund interest is assumed at 2%, which is projected "real" long-term growth of the fund after inflation. Growth of fund beyond 2% is conservatively assumed to be balanced by a corresponding increase in long-term care costs due to inflation.
- The projection assumes withdrawals from the long-term care fund for potential remedial actions. The projection assumes a combination of pump-and-treat remediation costing $30 million over the first 20 years of institutional control and replacement of enhanced caps on all trenches ($18.75 million over the first 10 years).

FIGURE 8-1
LONG TERM CARE FUND BALANCE

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9.0 REVIEW OF CLOSURE PERFORMANCE OBJECTIVES

This section lists the License 097 closure performance objectives. The method by which CNS complies or will comply with each objective is summarized. Specific sections of the Closure Plan are referenced, as appropriate, to provide a more complete discussion.

9.1 Objective A

"Bury all waste in accordance with the requirements of the license."

CNS operates the Barnwell site under License 097. To meet license requirements regarding waste burial, CNS has established procedures, trained its personnel in their use, and assigned specific individuals responsible for ensuring CNS compliance.

To help assure that the requirements of the licenses are met, DHEC has assigned an official to the facility to inspect incoming shipments and burial operations. DHEC engineers inspect and approve each disposal trench during its construction. DHEC performs frequent inspections of the CNS operations and records, including periodic formal audits.

In addition to DHEC's inspections, CNS conducts an internal audit program to evaluate compliance with licensing requirements. Audit results are made available for review by regulatory agencies. The regulatory inspection programs are described further in Section 3.1.3.

9.2 Objective B

"Dismantle, decontaminate, as required, and dispose of all structures, equipment, and materials that are not to be transferred to the site custodian."

Most structures within the restricted area fence will be dismantled and disposed on site. Contaminated materials will be properly buried. The on-site vehicles and heavy equipment will be decontaminated and removed from the facility. The anticipated disposition of each building and structure and methods proposed for decommissioning are discussed in Section 6.1

9.3 Objective C

"Document the arrangements and the status of the arrangements for orderly transfer of site control and for long term care by the government custodian. Also document the agreement, if any, of state or federal governments to participate in, or accomplish, any performance objective. Specific funding arrangements to assure the availability of funds to complete the site closure and stabilization plans must be made."

The State of South Carolina owns the property that CNS uses for the disposal of low-level radioactive waste. Chem-Nuclear has a long-term Lease Agreement with the State Budget and Control Board for use of this land. At completion of Phase II post-closure observation, this property will revert to State ownership and management in accordance with the site transfer mechanism discussed in Sections 7.0 and 11.0.

No performance objective to be accomplished by the State of South Carolina or any agency of the federal government has been identified.

A decommissioning fund has been established by means of the Trust Agreement between CNS and the State Budget and Control Board. CNS and DHEC evaluate the adequacy of these funds at each Closure Plan update. Closure funding is discussed in Section 6.11.

9.4 Objective D

"Direct gamma radiation from buried wastes should be essentially background."

Direct gamma surveys of completed trenches are conducted when trenches are closed. The surveys are performed at thirty inches above the ground surface to ensure that adequate cover thickness is being placed over the wastes. Previous surveys indicate that this performance objective will be met. During closure, after completion of the final disposal trench, CNS will perform a final site survey, including direct gamma, as described in Section 6.1.5.

9.5 Objective E

"Demonstrate by measurement/and or model during operations and after site closure that concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals will not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public."

To demonstrate compliance with this objective, CNS will update its radionuclide migration projection and dose assessment as summarized in Section 6.6. At the time of disposal site closure, CNS anticipates surface on- and off-site measurements of radioactivity will be consistent with background except for tritium and carbon-14, which have been identified in groundwater and in surface water in Mary's Branch creek. Section 5.4 summarizes the current measured radioactivity in groundwater (CNS, 2000b).

9.6 Objective F

"Render the site suitable for surface activities during custodial care. Planned custodial care may be limited to activities such as vegetation control, interim maintenance, and environmental monitoring. However, use of the site surface for activities such as parking lots may be planned. Final conditions at the site must be acceptable to the custodial agency and compatible with its plans for the site."

The site surface will be gently sloped and vegetated to minimize erosion. CNS has not proposed a use for the site surface.

9.7 Objective G

"Demonstrate that all trench bottom elevations are above water table levels, taking into account the complete history of seasonal fluctuations."

CNS designs trenches at the Barnwell site to ensure at least five feet of separation between trench bottom and maximum recorded historical water table level. In 1998, a new high water table was observed, establishing a new water table baseline at the site. CNS will use this baseline to design future trenches.

9.8 Objective H

"Eliminate the potential for erosion or loss of site or trench integrity due to factors such as groundwater, surface water, wind, subsidence, and frost action. For example, an overall site surface water management system must be established for humid sites to drain rainwater and snowmelt away from the burial trenches. All slopes must be sufficiently gentle to prevent slumping or gullying. The surface must be stabilized with established short-rooted grass, rock, riprap, or other measures. Trench caps must be stabilized so that erosion, settling, or slumping of caps does not occur."

Surface water erosion will be minimized by gentle sloping, vegetation, and proper water management as described in Section 6.2.2. Precipitation will drain away from burial trenches to the surface water management basins shown on Figure 6-1. The basins are designed to contain anticipated sedimentation and the 100-year storm volume.

9.9 Objective I

"Demonstrate that trench markers are in place, stable, and keyed to benchmarks. Identifying information must be clearly and permanently marked."

CNS uses a grid system at the site for horizontal control of site features and trench location. A set of permanent CNS benchmarks has been established across the licensed disposal area for use during surveying, as described in Section 6.4. The system uses Monuments SRO No. 123 and No. 128 to form a north/south baseline. This baseline, approximately 10^{o} 10' west of magnetic north, forms the western boundary of the site's exclusion area.

The trench corner markers are located and emplaced using the reference monuments and benchmarks discussed above. Each corner of each trench will be identified with a marker, and trench identification markers will be installed for each trench with the information prescribed in Section 6.2.3.

9.10 Objective J

"Compile and transfer to the Department complete records of site maintenance and stabilization activities, trench elevation and locations, trench inventories, and monitoring data for use during custodial care for unexpected corrective measures and data interpretation."

Waste and site monitoring data are routinely transmitted to DHEC monthly and quarterly. CNS and DHEC share trench drawings and construction information throughout the evaluation, approval, construction, use, and completion stages of each trench. Complete sets of these and other records described in Section 7.2 will be transferred during the closure period.

9.11 Objective K

"Establish a buffer zone surrounding the site sufficient to provide space to stabilize slopes, incorporate surface water management features, assure that future excavation on adjoining areas would not compromise trench or site integrity, and provide working space for unexpected mitigating measures in the future. The buffer zone must also be transferred to the custodial agency. The buffer zone may generally be less than 300 feet but not less than 100 feet."

A 100-foot buffer zone has been maintained within the current licensed disposal area boundary. CNS' plan for boundary revisions and buffer zone for long-term institutional control are described in Section 6.7. The boundary will be revised to provide sufficient space to manage surface water, maintain site surface stability and for monitoring. CNS proposes to transfer all land within the proposed boundary to the State of South Carolina.

9.12 Objective L

"Provide a secure passive site security system (e.g., a fence) that requires minimum maintenance."

A fence will be installed around the closed disposal site, providing a passive security system. Fencing specifications and physical security of the site are discussed in Section 6.1.6.

9.13 Objective M

"Stabilize the site in a manner to minimize environmental monitoring requirements for the long term custodial phase and develop a monitoring program based on the stabilization plan for implementation by custodial agency."

Monitoring during long-term care is described in Section 8.6, including a brief discussion of the planned monitoring well population. CNS proposes to significantly reduce monitoring during closure and long-term care. CNS will perform an evaluation and select monitoring wells for long-term monitoring. The long-term program will be developed based on accepted environmental monitoring programs and practices incorporating CNS' detailed understanding of site geohydrologic characteristics.

9.14 Objective N

"Investigate the causes of any statistical increases in environmental samples which have occurred during operation and stabilization. In particular, any evidence of unusual or unexpected rates or levels of radionuclide migration in or with the groundwater must be analyzed and corrective measures implemented."

CNS notifies DHEC when environmental data indicate changes in radiologic conditions at the site. In the event of unexpected changes, DHEC is immediately notified. For small and expected variations, DHEC is informed by normal reporting procedures.

Based on CNS findings of above-background radioactivity, CNS has implemented corrective measures. In 1991, CNS started installing enhanced caps. So far, CNS has covered 80 acres of trench as described in Section 6.2.1. As required by License 097, CNS will cover all existing trenches with enhanced caps.

9.15 Objective O

"Eliminate the need for active water management measures, such as sump or trench pumping and treatment of the water to assure that wastes are not leached by standing water in the trenches."

The final grading and stabilization of the site will include proper sloping, topsoiling, and vegetation to minimize infiltration. These actions and enhanced caps will minimize infiltration of water into the trenches and reduce or eliminate the need for pumping or treatment of trench water. CNS has observed little or no water accumulation in trenches after enhanced cap installation.

9.16 Objective P

"Evaluate present and zoned activities on adjoining areas to determine their effect on the long-term performances of the site and take reasonable action to minimize the effects."

Immediately west of the disposal facility, Barnwell County is developing an industrial park. CNS has and will continue to interface with the development board to determine potential impacts to long-term site performance. CNS knows of no other significant developments planned for areas adjoining the facility.

10.0 REASSESSMENT OF OPERATING PRACTICES

CNS performed a reassessment of site operations in conjunction with preparing this Closure Plan revision. This reassessment is intended to identify operational improvements and activities that may contribute to the objectives of this plan. Current and relevant recommendations from recent closure plans are discussed below.

10.1 Trench Construction and Disposal Operations

Recommendation: (1) Evaluate trench design, construction and disposal methods to improve trench water management. CNS' goal is to design trenches for a minimum accumulation of surface water, and to manage trench water to the extent possible within active disposal trenches. (2) Design trenches to best accommodate projected waste types and forms over the coming years. CNS foresees changes in waste types received and the continued receipt of large-components. Trench designs must be customized to facilitate efficient and safe offload of such waste.

Status: During 1999, CNS implemented new water management procedures and practices. These procedures improve management of trench storm water and specify processes for percolation and evaporation of accumulated waters.

CNS has, in the past, modified trench designs to facilitate large component disposal. CNS will continue to follow and project industry trends to anticipate future shipments and design trenches for enhanced disposal efficiency and stability.

10.2 Enhanced Caps

Recommendation: CNS should continue installing enhanced caps on completed trench areas during site operations. CNS has committed to capping all disposal trenches. CNS should schedule and locate trenches to consolidate areas for capping at the earliest possible time. This will minimize the cost and effort at closure.

Status: CNS has completed five capping phases covering 80 acres. The CNS Least Cost Operating Plan (CNS, 2000a) schedules another 32 acres for capping during the next eight years.

Capping these areas maximizes site performance and long-term stability. Indications of effective cap performance include seepage of water from the drainage layer around the perimeter of the cap after rainfall, drying of trench sumps, and near-cap reductions in tritium concentrations. CNS will continue to provide DHEC with updates of tritium concentration in environmental monitoring reports and as part of performance assessment during site closure.

10.3 Equipment and Structure Disposition

Recommendation: CNS recommends that any structures or equipment not needed for CNS operations or to be retained during closure be removed or disposed as soon as possible. Unusable and unsalvageable equipment in the operations areas of the site should be properly dispositioned. These actions will minimize the effort required during the closure period.

Status: Since 1994, CNS has significantly reduced the amount of scrap material on and around the site. Heavy equipment in CNS and contractor storage yards has been removed. CNS directed removal of a large above ground (12,000 gallon) gravity-feed diesel fuel tank. Assorted equipment and scrap has been removed from ancillary facility areas.

The remaining underground fuel storage tanks and the on-site Electro-Con Facility have been decommissioned.

CNS plans to continue such clean-up and decommissioning activities.

10.4 Surface Water Management

Recommendation: CNS should improve surface water management on the west side of the disposal site to minimize active management. In 1998, large volumes of surface water accumulated on the west side of the site, backing-up close to trench areas and to levels requiring active pumping. The large volumes were due to high rainfall and the additional runoff from increased areas of enhanced cap. CNS should re-design water management features and processes to eliminate active water management such as pumping.

Status: In 1999, CNS submitted a conceptual design plan to DHEC and has received approval to proceed. CNS plans to construct water management improvements during 2000 and 2001.

10.5 Least Cost Operating Plan Implementation

Recommendation: CNS recommends that site operations and closure activities be performed in accordance with the Least Cost Operating Plan (CNS, 2000a) schedule. The schedule integrates disposal and closure tasks for efficient use of CNS resources. Implementation of this plan will allow certain site closure activities to be completed as soon as possible. CNS should continue operations and implement closure of the site in accordance with this plan. DHEC approvals for key site closure tasks will be obtained as required.

Status: LCOP is being submitted in conjunction with this plan.

11.0 SITE CLOSURE IMPLEMENTATION TASKS

Previous sections of this document have discussed the activities required to complete site closure and stabilization, the maintenance and monitoring activities needed for long-term care, and the adequacy of the current financial arrangements. This section identifies the proposed administrative process for effecting site closure and transfer to the custodial agency. This implementation plan outlines the schedule of activities to be performed during the remainder of operations, Phase I closure, Phase I post-closure observation and into the long-term care period. Use of this plan will ensure effective and efficient transition of the site into the long-term care period.

11.1 Operational Period Tasks

CNS has performed disposal activities and site operations in accordance with the regulatory requirements established throughout the operational phase of the site. Any deficiencies discovered have been promptly corrected with regulatory agency concurrence. The site monitoring programs have expanded to provide an understanding of site performance. Closure of each trench is performed as a routine part of disposal operations. Certain significant closure activities, for example enhanced capping, have already been performed.

Based on our evaluations, CNS recommends that closure of the site be performed in accordance with the Closure Plan. CNS will request that the Budget and Control Board of the State of South Carolina authorize the disbursement of monies from the Trust Agreement fund to perform Closure Plan activities. Such authorizations have been made in the past. CNS anticipates additional authorizations will be required during site operations as CNS continues to implement closure tasks. Another authorization may be required prior to the start of the Phase I closure period. Any authorizations depend on DHEC concurrence with proposed use of fund monies. The following tasks will be accomplished in order to receive funds from the Trust Agreement accounts.

- Obtain a current statement of funds available in the Principal Account and the Income Account from the Treasurer of the State of South Carolina (State Treasurer).

- Obtain written authorization from an authorized representative of the State Budget and Control Board to direct the distribution of the requested funds to Chem-Nuclear Systems, LLC.

The existing fund with the proposed funding mechanism will be sufficient to complete the site closure activities discussed in this document.

The activities proposed to complete closure have been evaluated to ensure that the established site closure and stabilization performance objectives will be met. Also, the cost to complete the final closure activities has been compared with existing monies in the decommissioning fund. S1129 states that in the event of inadequate funds CNS may obtain the remainder of the monies needed from the long-term care fund. Also, any funds remaining after completion of Phase I closure will be used for post-closure observation/long-term care expenses.

11.2 Phase I Closure Period Tasks

The activities discussed in Section 6.0 will be performed to complete the closure and stabilization of the Barnwell site. It is expected to take CNS about 18 months to complete these closure activities. The buildings will be surveyed and prepared as necessary for safe dismantlement and disposal on-site. The equipment not needed for in-region operations will be surveyed, decontaminated, if necessary, and removed from the site. The site surface areas will be surveyed and contamination found will be removed. All contaminated items and materials will be placed in a waste disposal trench.

The disposal site areas will be graded and contoured to provide gentle slopes for proper surface water drainage away from trenches. The disturbed areas will be topsoiled and reseeded with native vegetation, as appropriate, and the final radiological survey of the disposal trenches will be performed. The installation of the permanent trench corner markers and identification markers will be completed. Site monitoring and maintenance will continue during the closure period and will be paid for with closure funds.

CNS intends to perform these closure and stabilization activities with monies being held in the Decommissioning Trust Account. The existing site personnel will be used to complete site closure, supplemented with contractors, as appropriate. Site personnel are familiar with the site, previous activities that have taken place, and methods to be used to perform closure safely and efficiently. Personnel qualifications, existing training programs, site equipment, and instrumentation have all been reviewed and accepted by DHEC.

The following tasks will be accomplished to ensure that site closure can be completed in a proper and timely manner.

- Obtain a current statement of funds available in the Principal Account and the Income Account from the Treasurer of the State of South Carolina.

- Submit the final Closure Plan one year prior to start of closure. The final Closure Plan will document the closure activities completed to date and outline the remaining activities required for site decommissioning and closure.

- Obtain written authorization from the State Budget and Control Board directing distribution of the trust estate funds to CNS in accordance with a mutually agreed-upon schedule.

- Establish the administrative control mechanisms, that will be used to gain DHEC concurrence for completion of specific site closure activities.

11.3 Phase I Post Closure Observation Period Tasks

At the end of Phase I closure activities, CNS will monitor the site for approximately five years to give DHEC sufficient opportunity to determine that the requirements of closure have been met. Near the beginning of post-closure, CNS will submit a performance objectives criteria report, which will establish the basis for achieving objectives. During year three and based on data review during the post-closure observation period, CNS will prepare and submit a final performance objectives evaluation report demonstrating compliance with performance objectives.

The site property is leased from the State Budget and Control Board by CNS in accordance with the Lease Agreement. Adjustment of the leased property boundaries of the site will be proposed by CNS (Section 6.7) to provide adequate area for the continued stability of the buried waste and the planned maintenance and monitoring activities. Considerations for the future use of any remaining facilities and adjacent areas held by CNS will be made in establishing the final site boundaries. In order to minimize the properties that will be unavailable for other uses and minimize the maintenance costs, the final site boundaries should include only properties necessary for proper long-term care of the buried wastes.

CNS will establish mechanisms with South Carolina Budget & Control Board for the routine distribution of monitoring and maintenance funds from the long-term care fund. These mechanisms should provide for the justification of funds requested and the accountability of funds received.

11.4 Long-Term Care Period Tasks

The long-term care period of the site will begin when Phase I site closure activities have been completed and upon satisfactory completion of the post-closure observation period. Long-term care will commence for the largest part of the disposal site, alongside in-region operations, which will impact only a small portion of the site. Monies held in the long-term care fund established by the Lease Agreement will be used to pay for the long-term care activities. Section 8.0 of this document details the long-term care activities and demonstrates that the funding for long-term care is more than adequate.

It may be necessary for the State Budget and Control Board and CNS to amend the current Lease. The following items in the current Lease should be addressed.

- Paragraph 1. (4-6-76) provides the legal description of the leased property. Property boundaries may be adjusted to provide the optimum property for site stability and long-term care.
- Paragraph 2. (4-6-76) states that the date of termination of this lease is April 5, 2075.
- Paragraph 7. (7-15-86) originally established the escrow account for surveillance and maintenance of the site. Several amendments to this

paragraph have resulted in increasing the payment to $2.80 for each cubic foot of waste as of the July 15, 1986 amendment.

- Paragraph 8. (9-11-79) requires CNS' compliance with regulatory requirements. Mutual agreement for CNS' continued use of the site for another reasonable purpose is allowed provided that the perpetual care fund is continued. The State Budget and Control Board will continue using the site for storage and disposal of radioactive waste.

The long-term care period is divided into four stages. Stage I is the first 36 years comprising in-region operations, Phase II closure, and Phase II post-closure observation; Stage II is the first 25 years of the actual institutional control period; Stage III is the second 25 years; and Phase IV is the final 50 years of institutional control. The annual routine maintenance and monitoring requirements should decrease over time since the disposal trenches will eventually stabilize and radioactive decay will reduce the waste inventory. The long-term care fund can support site maintenance and monitoring for a much longer period than 136 years and pay for remedial action, if required.

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13.0 SITE DRAWING

CNS drawing B-500-D-300, "10 Year Land Utilization Plan" shows current status and future plans for disposal operations at the Barnwell Site.

DRAWING B-500-D-300
AVAILABLE IN HARDCOPY FORM ONLY